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ECONOMIC ANALYSIS OF EFFLUENT GUIDELINES. THE NONFERROUS METALS INDUSTRY (ALUMINUM)

ARTHUR D. LITTLE, INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

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This analysis of the economic impact of proposed water effluent guidelines on the Nonferrous Metals industry - Aluminum (SIC's 2819, 3334, and 3341) was prepared to supply EPA with the costs of pollution abatement requirements in compliance with the 1972 Federal Water Pollution Control Act Amendment for each of three standards: Best Practical Control Technology Currently Available, Best Available Technology Economically Achievable and Standards of Performance for New Sources.

It concentrates on the economic impact of the water pollution standards for the bauxite refining industry, the primary aluminum smelting and refining industry, and the secondary aluminum refining industry.

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Industrial Inorganic chemicals, Bauxite refining, primary aluminum production secondary smelting and refining of nonferrous metals (Aluminum only).

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ECONOMIC ANALYSIS
OF
EFFLUENT GUIDELINES
NONFERROUS METALS INDUSTRY
ALUMINUM

Report to

U.S. ENVIRONMENTAL PROTECTION AGENCY

AUGUST, 1974

1a

PREFACE

The attached document is a contractor's study prepared with the supervision and review of the Office of Planning and Evaluation of the U.S. Environmental Protection Agency (EPA). Its purpose is to provide a basis for evaluating the potential economic impact of effluent limitations guidelines and standards of performance established by EPA pursuant to sections 304(b) and 306 of the Federal Water Pollution Control Act.

The study supplements an EPA technical "Development Document" issued in conjunction with the promulgation of guidelines and standards for point sources within this industry category. The Development Document surveys existing and potential waste treatment and control methods and technologies within this category and presents the investment and operating costs associated with various control technologies. This study supplements that analysis by estimating the broader economic effects (including product price increases, continued viability of affected plants, employment, industry growth and foreign trade) of the required application of certain of these control technologies.

This study has been submitted in fulfillment of Contract No. 68-01-1541, Task No. 9 by Arthur D. Little, Inc. Work was completed as of August, 1974. The study is based primarily upon an earlier study, also prepared by Arthur D. Little, Inc., entitled "Economic Analysis of Proposed Effluent Guidelines for the Nonferrous Metals Industry". The earlier report was circulated in conjunction with the publication of the Federal Register of a notice of proposed rulemaking under sections 304(b) and 306 for the subject point source category. The analysis contained in the original study has been updated based upon information received during the period of time between publication of the notice of proposed rulemaking and the promulgation of final regulation. Because of the constraints of time, the control and treatment costs analyzed in this study may not in all instances be identical to those associated with the requirements of the promulgated regulation. However, those differences, when they exist, are minor insofar as the final conclusions of the study are concerned.

This report represents the conclusions of the contractor. It has been reviewed by the Office of Planning and Evaluation and approved for publication. Approval does not signify that the contents necessarily reflect the views of the Environmental Protection Agency. The study has been considered, together with the Development Document, information received in the form of public comments on the proposed regulation, and other materials in the establishment of final effluent limitations guidelines and standards of performance.

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I. EXECUTIVE SUMMARY

A. PURPOSE AND SCOPE

This study is aimed at supplying the Environmental Protection Agency with information regarding the economic impact of the costs of pollution abatement requirements under the Federal Water Pollution Control Amendments Act of 1972 for each of the three standards:

1. Best Practicable Control Technology (BPT) - to be met by industrial dischargers by 1977.
2. Best Available Control Technology (BAT) - to be met by 1983.
3. New Source Performance Standards (NSPS) - to be applied to all new facilities (that discharge directly to navigable waters) constructed after the proposal of these guidelines (June 3, 1974).

The scope of this study is concentrated on specific parts of the aluminum industry, namely:

- SIC 2819 - Bauxite Refining Only
- SIC 3334 - Primary Aluminum Production
- SIC 3341 - Secondary Smelting and Refining of Nonferrous Metals (aluminum and aluminum base alloys only).

At the outset of the study, an initial examination was made to determine which of the above three areas of the aluminum industry deserved more attention from the standpoint of potential water pollution problems. A cursory examination revealed that primary aluminum production had a lower water requirement than do the other two areas. For this reason and others discussed later, it was decided to concentrate the available time and effort on the economic impact of the water pollution standards on the bauxite refining industry and the secondary aluminum smelting and refining industry. A summary of the initial examination of the primary aluminum sector is included in this summary.

B. PRIMARY ALUMINUM INDUSTRY

1. Air Pollution

Of major concern to the primary aluminum industry are proposed air pollution standards. The air pollution standards for existing sources are being set so that there will be a net emission to the atmosphere of two pounds of fluoride per ton of aluminum produced. This standard was established on the basis of using a dry scrubbing system on the pot line off-gases. There is adequate data on pre-bake pot lines (the Alcoa 398 process) that shows that this is achievable and apparently there is also extensive European data and limited U.S. data on vertical stud Soderberg pot lines to indicate that they would also not have any problem. As far as horizontal stud Soderberg plants are concerned, management at one plant feels reasonably confident that a dry scrubbing system will be successful. If not, they would be forced to go to a wet system probably using higher pressure drop scrubbers than they have at the present time. Thus, indications are that the air pollution problems will be solved by a dry process and will not create a water pollution problem.

Costs

Table I-1 presents order-of-magnitude estimates of capital investment and annual costs required for the primary aluminum industry to meet the proposed air quality regulation of two pounds of fluoride emitted to the atmosphere per ton of aluminum produced. The costs are presented according to cell type; pre-bake, horizontal stud Soderberg, and vertical stud Soderberg cells. From Table I-1, it can be seen that the annual costs of air pollution control for the entire industry is approaching 1¢/lb. of aluminum produced.

2. Water Pollution

The trend in air pollution control is toward the use of dry scrubbers, thus,eliminating a potential water pollution problem. For this reason, there seems to be less concern in industry about water pollution than about air pollution.

The water pollution regulations set forth by the Effluent Guideline Development Document are summarized in Table I-2. These regulations are a product of the work the EPA has done in contacting the industry and determining what the industry is capable of doing.

Costs

Costs for complying with the above regulations were developed by the EPA and are presented in Table I-3. The costs are not additive,

TABLE I-1

COSTS REQUIRED TO MEET PROPOSED AIR EMISSION STANDARDS PRIMARY ALUMINUM INDUSTRY

Cell Type	Industry Capacity (Million lbs/yr.)	Capital Investment		Annual Cost*	
		Million $	¢/lb.	Million $	¢/lb.
Pre-bake	6,222	171	2.75	48	0.77
Horizontal Stud Soderberg	2,122	123	5.8	34	1.6
Vertical Stud Soderberg	902	29	3.25	8	0.9
Totals	9,246	323	3.5	90	0.97

*Including Depreciation and Interest

SOURCE: ADL Estimates

TABLE I-2

EFFLUENT LIMITATIONS FOR WASTEWATER FROM PRIMARY ALUMINUM OPERATIONS

(lb/1000lb. of Aluminum Produced)

PARAMETER	B.P.T.	B.A.T.	N.S.P.S.
Fluoride	1	0.05	0.025
Suspended Solids	1.5	0.1	0.05
pH	6-9	6-9	6-9

SOURCE: Effluent Guideline Development Document

TABLE I-3

COSTS REQUIRED TO COMPLY WITH PROPOSED WASTEWATER EFFLUENT LIMITATIONS FOR THE PRIMARY ALUMINUM INDUSTRY

(¢/lb. of Aluminum Produced)

GUIDELINE	CAPITAL INVESTMENT	ANNUAL COST
BPT	0.45	0.21
BAT	0.52	0.24

SOURCE: Environmental Protection Agency

i.e., the cost presented to meet BAT is the total cost required and is not added to the previous number for BPT.

When comparing these costs to those presented earlier for compliance with the air pollution regulations, it is obvious that the costs for water pollution control in the primary aluminum industry are significantly less than those applied to air pollution control.

Because of the less significant cost of water pollution control and because of industry's de-emphasis of water pollution problems as opposed to air pollution problems, this study has been focused toward the economic impact of water pollution regulations on the bauxite refining portion of the primary aluminum industry. However, the possibility still exists that the individual states may set more rigid air quality limitations beyond the capabilities of dry scrubbers. If this occurred, the primary aluminum smelters would have to install wet scrubbers (for example, for cleaning pot room air) and, as a result, would be faced with a water problem plus increased air pollution control costs. This could be very serious if the investment had already been made in one type of pollution control system which might become obsolete. This would also increase the total pollution related cost impact on the primary aluminum industry.

C. BAUXITE REFINING INDUSTRY

1. BPT and BAT Standards

The BPT and BAT effluent limitations are identical for this industry, i.e., no discharge of process waste water pollutants. Two plants within the bauxite refining industry will be significantly impacted by the BPT and BAT standards. These two plants are owned by one aluminum company and the output from these two plants represents more than 74% of the company's alumina supply for producing primary aluminum.

Because of prior compliance with a consent decree between EPA and the company, the two plants were given a variance from the BPT limitation, but not from the requirement for BAT. Therefore, the BPT and BAT effluent limitations of "no discharge" will result in added annual operating costs of 0.6 and 0.7¢/lb of aluminum, respectively, which are significant. (Note that these costs are not additive.)

The costs incurred by these two plants would be difficult to pass on to the consumer since the plants sell a portion of their product to other producers and the plants represent only 24 percent of the industry capacity. Any increase in price would place them in an unequal competitive position.

Closure is not probable as a result of the BPT limitation since about 80 percent of the capital investment required for BPT has already been committed at the two plants due to the terms of the consent decree. The two plants will therefore have to absorb the increased operating costs.

For the two plants, the costs for meeting BAT are even higher than those for meeting BPT. However, since the BAT requirement does not have to be met until 1983, perhaps a more suitable technology could be developed in this time period. If the decision were to shut down the two plants, given the added time a more orderly transition would be possible.

2. NSPS Standard

The NSPS requirement is identical to those for BPT and BAT. If a new bauxite refining facility were to be built today in the U.S., a location could be chosen which would allow the facility to meet the no discharge requirement without much difficulty. However, when considering all factors and trends, it is not likely that a new bauxite refinery will be constructed in the continental U.S.; the last was built in 1959.

D. SECONDARY ALUMINUM SMELTING AND REFINING INDUSTRY

1. Impact of the BPT Standards

There will be small increases in annual costs due to the BPT standards. These costs are less than 0.5¢/lb of product and in most cases are less than 0.2¢/lb. Because of the strong competitiveness of the industry, the costs are not likely to be passed on to the consumer but must be absorbed by the particular plants affected. However, this is not expected to result in any plant shutdowns.

2. Impact of the BAT Standards

The impact of the BAT standards will be to close the segment of the industry having to do with the wet processing of drosses. This involves the closing of three small plants, one large plant, and two wet dross departments in larger plants.

These closings would result in a loss of about three percent of the secondary aluminum industry's production capacity and a loss of a total of about 160 jobs or about three percent of the secondary aluminum industry's employment.

3. Impact of the NSPS Standards

The NSPS standards are identical to those for BAT. Therefore, the resultant impact will be to discourage the construction of new wet dross processing plants and favor dry processing approaches.

II. BAUXITE REFINING

A. INTRODUCTION

This portion of the study is to supply the Environmental Protection Agency with information regarding the economic impact on the U.S. bauxite refining industry of the costs of pollution abatement requirements under the Federal Water Pollution Control Amendments Act of 1972 for each of the three standards:

1. Best Practicable Control Technology (BPT) - to be met by industrial dischargers by 1977.
2. Best Available Control Technology (BAT) - to be met by 1983.
3. New Source Performance Standards (NSPS) - to be applied to all new facilities (that discharge directly to navigable waters) constructed after the promulgation of these guidelines (June 3, 1974).

The primary aluminum industry is comprised of bauxite mining, bauxite refining or alumina production, and the reduction of alumina to aluminum. These three stages in production tend to occur in different physical locations because of raw material and energy supplies and market locations, and have different technologies and cost functions.

1. Raw Materials

In nature aluminum is invariably combined with other elements. There are three known hydrated aluminum oxide minerals with fairly well defined geographic distribution which are generally referred to as bauxites. Gibbsite, the only naturally occurring form of aluminum trihydrate ($Al_2O_3 \cdot 3H_2O$), contains 65.4 percent alumina and 34.6 percent water. Boehmite and diaspore (alpha monohydrate, $Al_2O_3 \cdot H_2O$) each contain 85 percent alumina and 15 percent water. Diaspore is not used to produce alumina commercially.

Bauxite is classified into Jamaican, Surinam, and European types. The first contains both trihydrate and monohydrate, the second trihydrate only, and the third contains all grades but is mostly boehmite (monohydrate).

a. Bauxite Reserves

Domestic bauxite reserves are limited (see Table II-1) and U.S. Bayer plants are almost totally dependent on imported ores, as discussed later.

TABLE II-1

WORLD BAUXITE RESERVES, 1972
(Thousand Long Tons)

Country	Grade (% Al_2O_3)	Quantity	Percent of Total
United States	50	45,000	0.3
Australia	50	4,500,000	29.8
France	58	60,000	0.4
Greece	54	150,000	1.0
Guinea, Republic of	54	4,000,000	26.8
Guyana	58	100,000	0.7
Jamaica	50	800,000	5.4
Surinam	58	600,000	4.0
Other Free World	55	4,000,000	26.8
Communist Countries (except Yugoslavia)	50	700,000	4.6
World Total		15,000,000(1)	100.0(1)

(1) Totals may not add due to independent rounding.

SOURCE: Commodity Data Summaries, Bureau of Mines, 1973

The location of new bauxite discoveries, both proven reserves and potential resources, suggest that an increasing proportion of the world's bauxite will be produced in Australia and Africa.

b. Bauxite Mining

Approximately 90 percent of total noncommunist world bauxite production is mined by open-pit methods except in Europe where bauxite mining is predominantly by underground methods. After mining, the bauxite is generally crushed, dried, and beneficiated before shipment to an alumina plant.

Aluminum is unique among nonferrous metals industries in that the mining and beneficiation of the ore generally represents a fairly small percentage of the total cost of primary metal production. Transportation costs, however, have had a noticeable effect on the location of alumina plants since they tend to be 25 to 50 percent of the delivered cost of bauxite in the United States, although the amount varies with the source of the bauxite.

In 1971, U.S. production of bauxite was 1,988,000 long tons or only about 3 percent of total world production of 61,981,000 long tons. Arkansas produces about 90 percent of total domestic output, with the remainder being produced by Alabama and Georgia. Alcoa and Reynolds account for most of the Arkansas production, which is mined entirely in Pulaski and Saline counties. Table II-2 shows the domestic mine production of bauxite over a ten year period.

In 1971, nearly 89 percent of the bauxite used by U.S. Bayer plants was imported. The two alumina plants in Arkansas consumed mainly domestic bauxite, whereas, the other seven used imported ore exclusively.

2. Bauxite Refining

The Bayer process is used universally for bauxite refining, with slight modifications due to the type of bauxite being processed. In this process, the bauxite is digested with caustic soda solution under pressure, giving a solution of sodium aluminate and leaving an oxide of iron ("red mud"). Reaction (1) shows this step:

$$Al_2O_3 + 2NaOH = 2NaAlO_2 + H_2O \qquad (1)$$

The solution of sodium aluminate is agitated with hydrated alumina "seed" crystals, thus, precipitating about 50 percent of the alumina as hydrated alumina according to reaction (2):

$$2NaAlO_2 + 4H_2O = Al_2O_3.3H_2O + 2NaOH \quad (2)$$

TABLE II-2

MINE PRODUCTION OF BAUXITE IN THE UNITED STATES
(Thousand Long Tons)

	Alabama & Georgia		Arkansas		
Year	Quantity	% of Total	Quantity	% of Total	Totals(1)
1962	99	7	1,270	93	1,369
1963	47	3	1,478	97	1,525
1964	39	2	1,562	98	1,601
1965	61	4	1,593	96	1,654
1966	78	4	1,718	96	1,796
1967	83	5	1,571	95	1,654
1968	83	5	1,582	95	1,665
1969	88	5	1,755	95	1,843
1970	213	10	1,869	90	2,082
1971	207	10	1,781	90	1,988

(1)Totals may not add due to independent rounding.

SOURCE: Minerals Yearbook, 1966; Minerals Yearbook Preprint, 1971.

The hydrated alumina is then calcined to remove the waters of hydration resulting in pure alumina.

Bauxite contains various amounts of impurities, chiefly silica, iron and titanium, intimately associated with the alumina. Metal of suitable purity cannot be made directly from bauxite because of these contaminants. The raw ore must be refined to a pure form of alumina before it is reduced to the metal, since the aluminum industry is based on the use of 99%+ aluminum in the manufacture of the various alloys and products.

Various modifications of the Bayer process are used for the commercial production of alumina. Several other processes (such as acid leaching) have been developed for refining bauxite or other aluminum bearing materials but these have yet to be utilized on a large scale for the production of alumina.

The primary function of the Bayer process is to separate pure alumina from the various impurities--silica, iron oxide, titanium oxide, etc. Several modifications of the Bayer process are used, depending on the type of raw ore to be processed. The American Bayer process is used on high-grade bauxites in which the alumina is present chiefly as a trihydrate, i.e., as gibbsite. The Combination process is most practical for low-grade (high silica) bauxite containing the alumina in the form of gibbsite. The European process, which is not practiced in the U.S. is used for ores in which the alumina occurs chiefly as the monohydrate, boehmite. A modified Bayer process is used for mixed ores which contain both trihydrate and monohydrate. There are different variations of this process depending on the characteristics of the particular ore.

a. American Bayer Process

The crushed and dried bauxite is ground to -10 mesh in dry form in large hammermills or in slurry form in rod mills. Ground lime and commercial soda ash, which react to form sodium hydroxide, are the other principal raw materials.

Digestion is a continuous operation. Bauxite and lime are weighed and placed in a mixer with a small portion of the recycled spent liquor. The slurry is pumped to the digester. The recycled liquor is reconcentrated with addition of fresh caustic soda and pumped through heat exchangers to the digester where it is mixed with the bauxite-lime slurry. The slurry is digested under pressure at about 300°F for approximately one-half hour which is sufficient to dissolve the alumina and render the silica insoluble as a sodium aluminum silicate.

The slurry from the digesters is discharged through a series of heat recovery vessles which drops the pressure to atmospheric pressure.

The steam flashed off is used for preheating the digester feed liquor. The slurry passes through sand traps, which remove the coarse sands, and then is sent to a clarification step.

The clear liquor from the clarification operation is cooled and pumped into large precipitation tanks (24 feet in diameter and about 80 feet high). At this point, the strong sodium aluminate solution contains 80 to 100 grams of Al_2O_3 and 100 to 125 grams of NaOH per liter. Precipitation is accomplished by adding "seed" hydrated alumina, which has been classified from previously precipitated material. The solution is allowed to cool slowly with agitation for a period of 1-1/2 to 2 days. Approximately 50 percent of the alumina is precipitated as hydrated alumina. The slurry is pumped off through a classification and washing system where the hydrated alumina is separated from the spent liquor solution, which is returned to the digesters for another cycle through the system.

The fine fractions of hydrated alumina are returned as "seed" to the precipitators. The coarse fraction advances to the calcining operation.

The coarse hydrate from the precipitators is filtered and washed and then calcined at approximately 2,000°F to remove the moisture and the chemically combined water of crystallization. This calcined product is anhydrous aluminum oxide or alumina, which is shipped to the reduction plants.

Before the spent liquor solution is returned to the digesters for recycling through the system, evaporation may or may not be required to maintain the desired concentration and volume of the sodium aluminate solution. The American Bayer process requires less evaporation than other modifications of this process.

b. Combination Process

With the advent of World War II, the domestic reserves of high-grade bauxite were being rapidly depleted. The Combination process was developed by Alcoa at that time largely as a conservation measure. This process makes possible the commercial use of large reserves of high-silica domestic bauxite. Two Combination process plants are now in operation near Bauxite, Arkansas--one operated by Alcoa and the other by Reynolds.

This process uses the American Bayer plant plus additional steps to recover alumina and soda from the Bayer "red mud." These additional steps are:

Preparation of the mud.--The settled mud slurry from the Bayer washing thickeners is further thickened by filtration to approximately 50 percent solids, which is kept agitated in large tanks. This mud, along with the proper amounts of limestone and soda ash, is fed into ball mills and ground to -200 mesh size.

Sintering.--The mud mixture from the ball mills is pumped into surge tanks from which it is fed into large rotary kilns. The free water is evaporated and the mixture is sintered at approximately 2,200°F. The reactions during sintering form dicalcium silicate and sodium aluminate.

Leaching the sinter.--The product from the sintering operation is mixed with water and ground in ball mills where the sodium aluminate goes into solution leaving an insoluble residue of impurities called "brown mud." The slurry is then filtered and washed and the mud is discarded in the mud disposal lake. Sodium aluminate filtrate from the filters is pumped back into the Bayer circuit.

Evaporation.--The use of low-grade bauxites produces large amounts of red mud which require a corresponding large amount of water for washing. Considerable additional water is used in leaching the sinter. Thus, this process involves considerable evaporation to maintain the proper liquor concentrations in the Bayer system. This evaporation load and the additional operations in processing the mud increase the power requirements of the Combination process.

c. European Bayer Process

The European Bayer process was developed to process the European bauxites in which the alumina occurs chiefly as the monohydrate, boehmite. The operating steps in the European process are similar to those of the American Bayer. The European process uses a higher digestion temperature, longer digestion periods, and much higher caustic soda concentration. The digester solution contains approximately 350 grams/liter of NaOH, which is roughly three times the concentration used in the American practice.

At these concentrations the caustic makeup cannot be generated from lime and soda ash in the digester; caustic soda prepared in an outside operation is used.

The strong sodium aluminate solution from the digester must be diluted to about one-third its concentration before going through the clarification and precipitation steps. This requires a large amount of evaporation to restore the concentration needed for digestion.

Some Caribbean bauxite deposits contain the alumina chiefly in the form of gibbsite, but there are large tonnage deposits in which the alumina occurs as a mixture of gibbsite and boehmite. Alumina can be extracted from these bauxites either by using the European type process or by a modification of the American Bayer process, which is more economical.

B. INDUSTRY SEGMENTS

1. Types of Firms

Until 1940 the Aluminum Company of America (Alcoa) was the only primary aluminum producer and bauxite refiner in the United States. The domestic bauxite refining industry presently consists of only five large corporations, all of which are fully integrated from bauxite mining through to, and including, fabrication of aluminum products. These companies, their dates of entry into alumina production, and their respective capacities for domestically produced alumina are shown in Table II-3. Of these, Alcoa, Kaiser, and Reynolds are 100 percent self-owned, Ormet is owned 50 percent by Olin Corporation and 50 percent by Revere Copper and Brass, Inc., while Martin Marietta Aluminum, Inc. is owned 82.7 percent by Martin Marietta Corporation.

There are nine bauxite refining plants in the United States. These are distributed fairly equally among the five large corporations (see Table II-4). Seven of the plants produce alumina primarily for the eventual production of aluminum metal. The alumina produced at each plant is consumed by the parent company for that specific purpose.

The other two plants, both located in Arkansas (see Table II-4), produce a variety of products for industries other than aluminum metal production. These two plants process primarily low-grade Arkansas bauxite using the Combination process as described earlier. This process utilizes a sintering step which results in a very pure, low-organic product. This alumina is more pure than that needed for aluminum production and is also, from first approximation, a higher cost product than alumina produced by the American and Modified Bayer processes and, therefore, may not be competitive as a raw material for the aluminum reduction industry. Products from these two plants are marketed world-wide for numerous applications in such areas as the chemical industry, refractories, and cements.

Of the five companies involved in domestic alumina production, Alcoa and Reynolds can be considered as being involved solely in the aluminum industry. The other three companies are either diversified or are owned by diversified companies. Kaiser is perhaps the most diversified of the five, with about 80 percent of its sales in aluminum and substantial interests in refractories, chemicals, fertilizers, and nickel. A portion of Martin Marietta's aluminum volume is in non-aluminum products such as titanium and special metals. The parent company, Martin Marietta Corporation, is a largely diversified conglomerate with interests in numerous areas including chemicals, metals, and construction. Ormet is not itself diversified but is owned by two well diversified companies;

TABLE II-3

BAUXITE REFINING COMPANIES IN THE UNITED STATES

Company	Date of Entry	Alumina Capacity, 1973 (Short Tons/Year)
Aluminum Company of America	1888	2,750,000
Kaiser Aluminum & Chemical Corp.	1942	1,935,000
Martin Marietta Aluminum, Inc.	1967	400,000
Ormet Corporation	1958	618,000
Reynolds Metals Company	1942	2,300,000
Total		8,003,000

SOURCE: ADL estimates.

TABLE II-4

BAUXITE REFINING PLANTS IN THE UNITED STATES, 1973

Company and Plant	Alumina Capacity (Annual Short Tons)	Date Built	Employment
Aluminum Company of America (Alcoa)			
Bauxite, Ark.	375,000	1951-52	1,375
Mobile, Ala.	1,025,000	1937	650
Point Comfort, Tex.	1,350,000	1957-58	650
Totals	2,750,000		2,675
Kaiser Aluminum & Chemical Corp.			
Baton Rouge, La.	1,040,000	1941-42	720
Gramercy, La.	895,000	1959	500
Totals	1,935,000		1220
Martin Marietta Aluminum, Inc.			
St. Croix, V.I.	400,000	1966	430
Ormet Corporation			
Burnside, La.	618,000	1957	430
Reynolds Metals Company			
Corpus Christi, Tex.	1,460,000	1952-54	900
Hurricane Creek, Ark.	840,000	1941	1,000
Totals	2,300,000		1,900
Grand Totals	8,003,000		6,655

SOURCE: ADL estimates.

Olin Mathieson Chemical Corporation and Revere Copper and Brass, Inc. Olin's primary interests are in the chemical industry, while Revere is one of the largest U.S. fabricators of copper, brass, and aluminum mill products. More specific information on these companies is given in the financial discussion (Section C).

2. Types of Plants

As mentioned earlier, there are only nine bauxite refining plants in the United States. This includes one located in the Virgin Islands. The other plants are located in Alabama, Arkansas, Louisiana, and Texas (see Table II-4).

All the plants in the U.S. have been built within the last thirty-five years. The facilities in Mobile, Baton Rouge, and Hurricane Creek date back to World War II. Those at Bauxite and Corpus Christi were constructed in the early 1950's and the plants at Point Comfort and Gramercy in the late 1950's. Martin Marietta's plant in the Virgin Islands was completed in 1967, and Ormet's plant in Burnside, La., started production in 1958. The capacities of some of the plants have been expanded over time, so not all the equipment at the plants is as old as the original construction dates would indicate. Presented here will be a brief description of each plant. Figures II-1 through II-5 present the alumina production capacities for each plant from the year of construction to the present.

a. Aluminum Company of America

Bauxite, Arkansas

This plant was built in 1951-52. Plant facilities are designed to use the Combination Bayer process to refine domestic bauxite supplied by nearby mines. As can be seen from Figure II-1, capacity has remained fairly constant. This phenomenon is due to the fact that domestic supplies of bauxite are limited and bauxite production has remained fairly constant over this time period.

The operations at this plant are very complicated. About 85 percent of its output is marketed throughout the world for various uses other than the production of aluminum metal.

Mobile, Alabama

This is the oldest operating plant in the U.S., constructed in 1938, and until 1967 was also the largest. Its growth was substantial in the mid-1950's, but has not expanded since then. The plant uses the Bayer process and operates on Surinam ore exclusively.

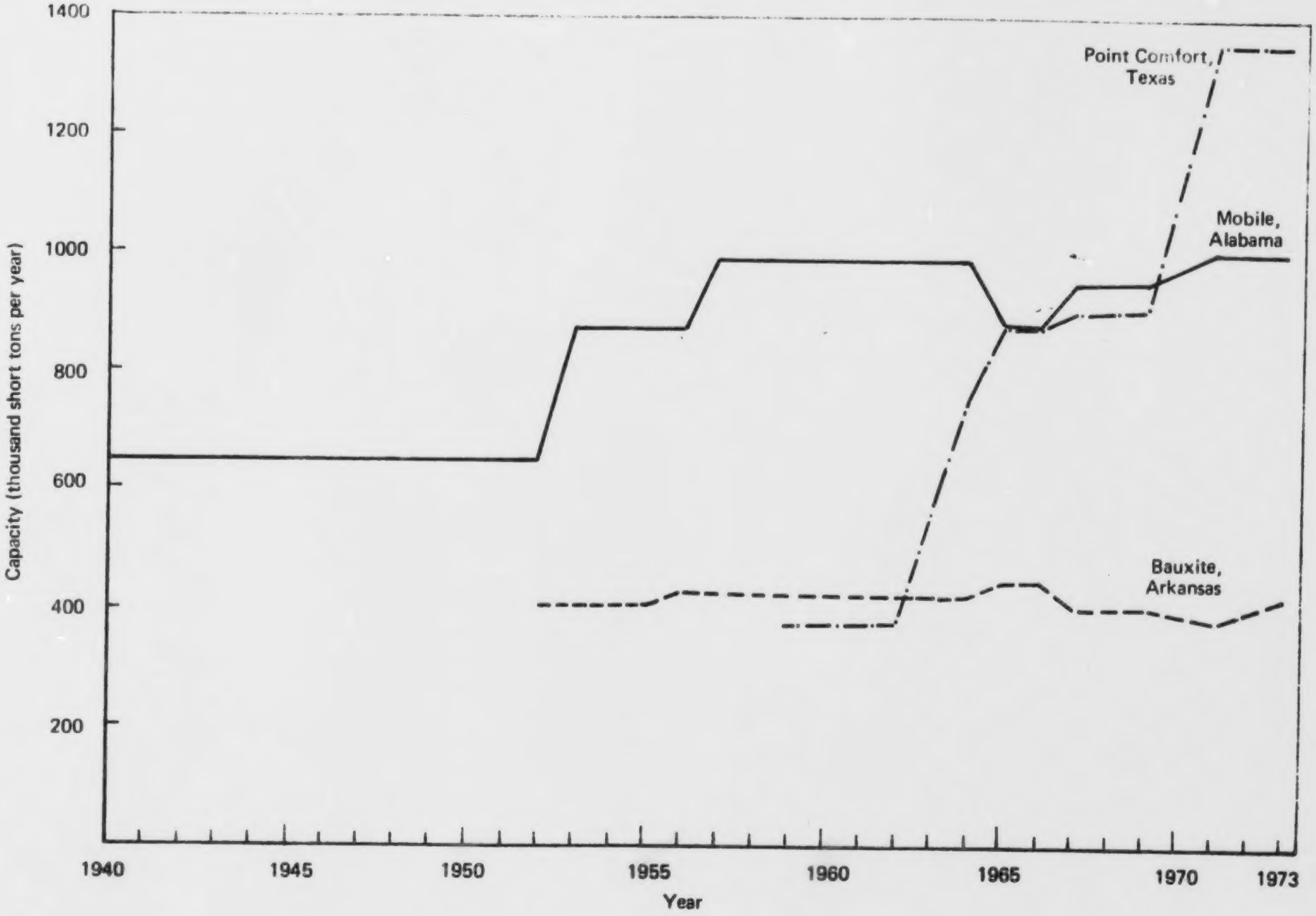

FIGURE II–1 ALUMINUM COMPANY OF AMERICA – GROWTH HISTORY OF DOMESTIC BAYER PLANTS

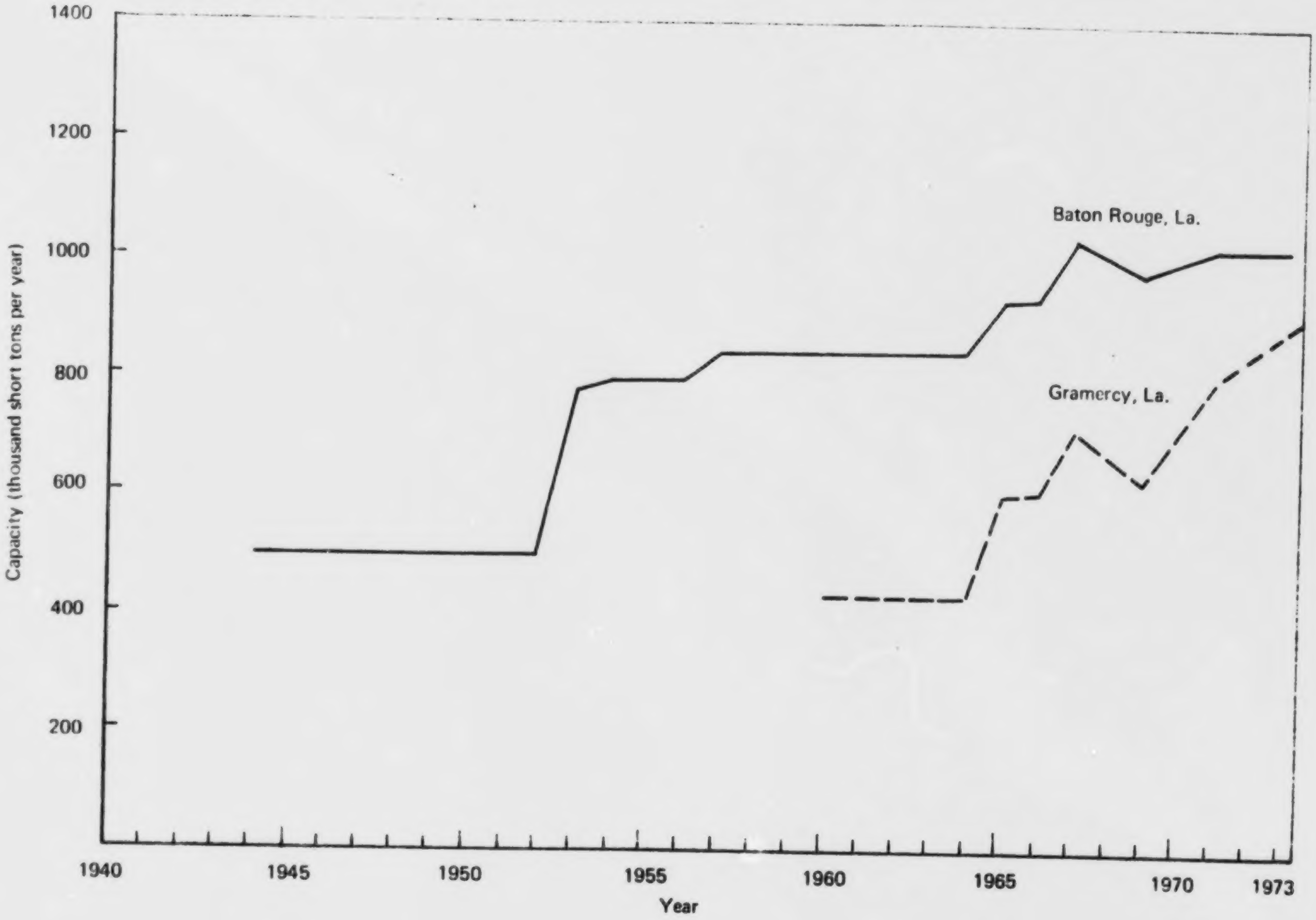

FIGURE II–2 KAISER ALUMINUM AND CHEMICAL CORPORATION – GROWTH HISTORY OF DOMESTIC BAYER PLANTS

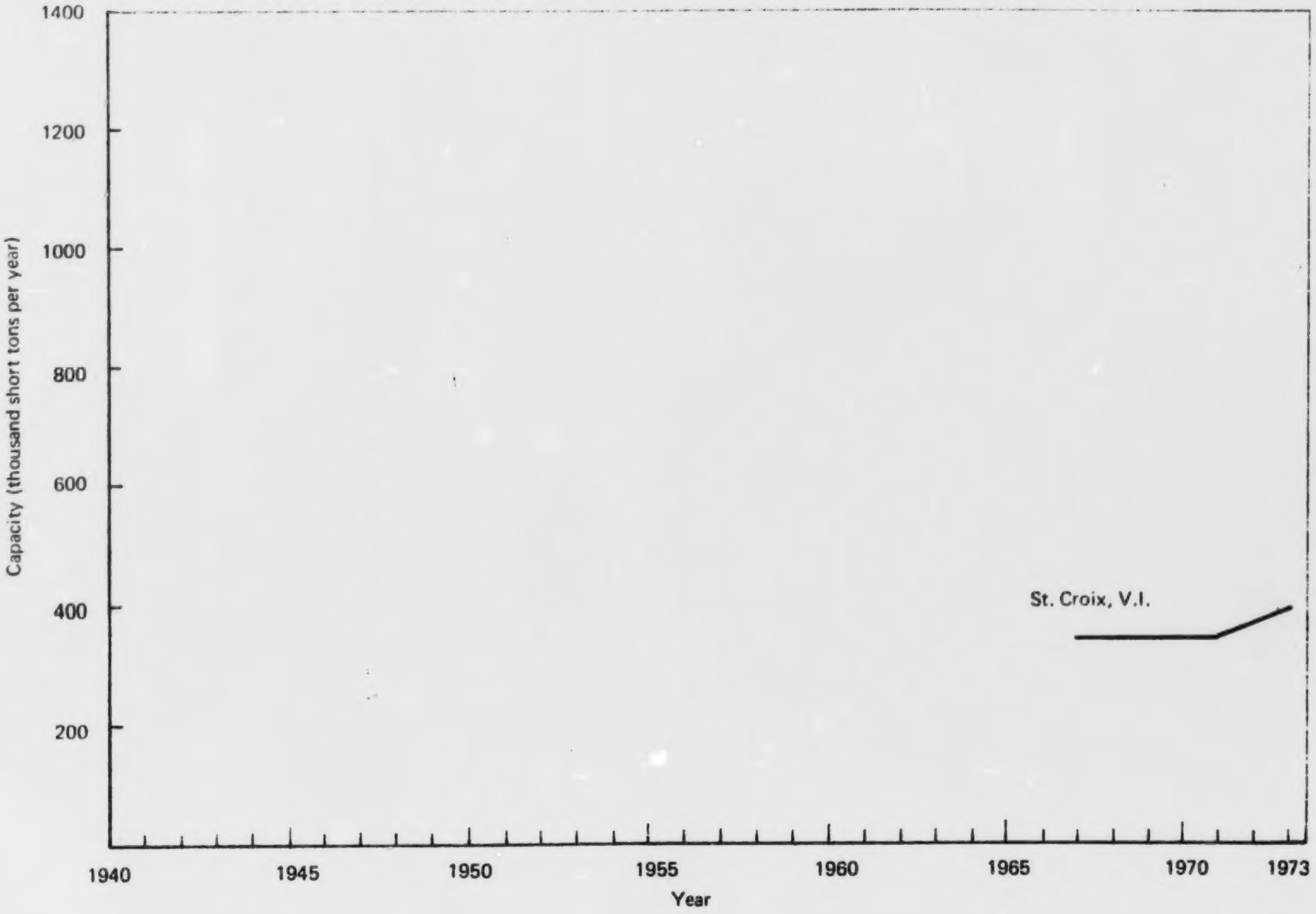

FIGURE II–3 MARTIN MARIETTA ALUMINUM, INC.–GROWTH HISTORY OF DOMESTIC BAYER PLANTS

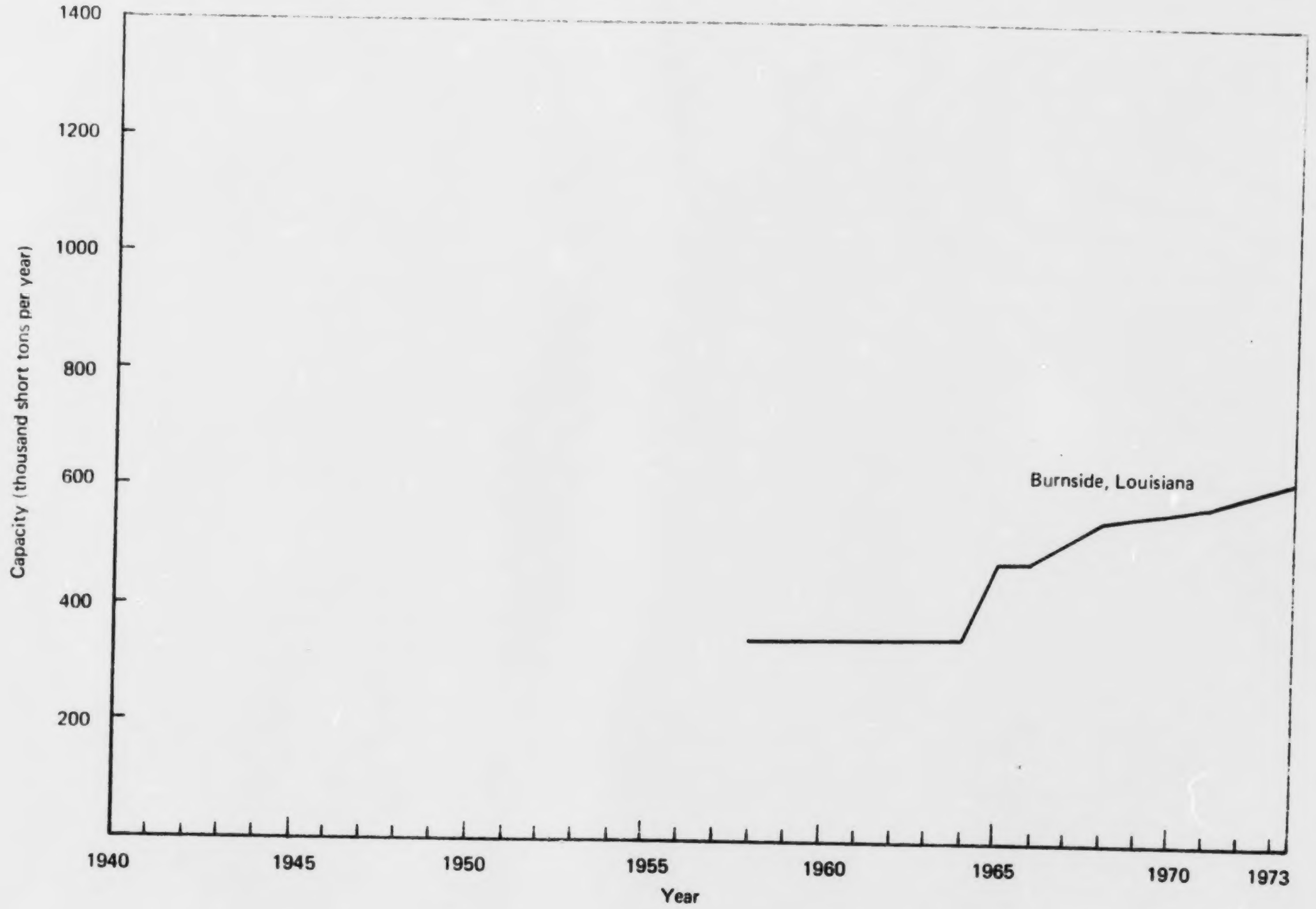

FIGURE II–4 ORMET CORPORATION – GROWTH HISTORY OF DOMESTIC BAYER PLANTS

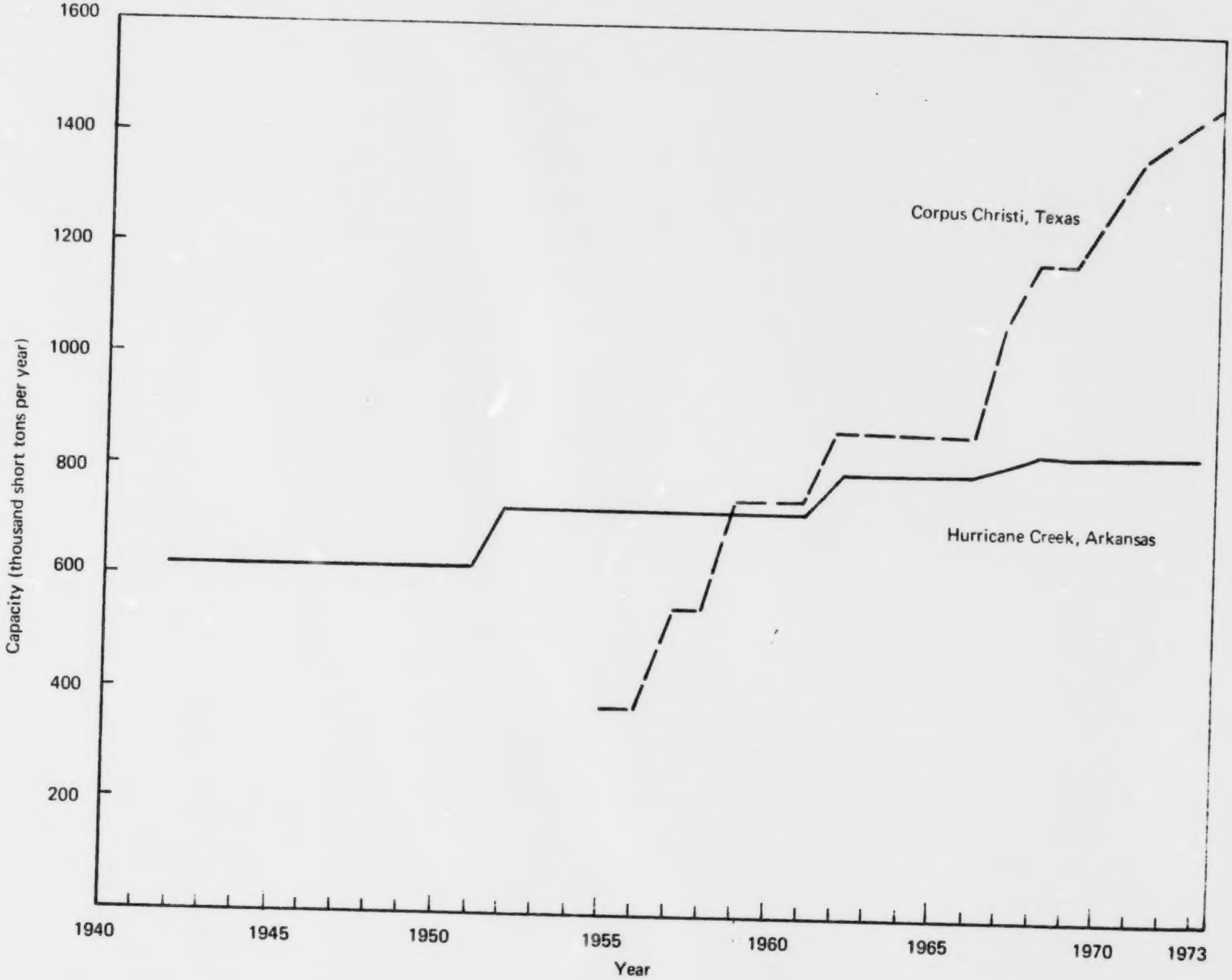

FIGURE II–5 REYNOLDS METALS CO. – GROWTH HISTORY OF DOMESTIC BAYER PLANTS

Point Comfort, Texas

This is Alcoa's newest bauxite refining plant and has experienced considerable growth since its construction. This is due to the facts that the plant obtains bauxite supplies from Alcoa's mines in Surinam, Jamaica, and the Dominican Republic and the aluminum plant is located near a company-owned primary reduction plant in Texas and is on the Gulf Coast, thus, minimizing transportation costs for both alumina and bauxite. This plant is using a slightly modified Bayer process since it is treating Jamaican ore which contains both gibbsite and boehmite.

b. Kaiser Aluminum & Chemical Corporation

Baton Rouge, Louisiana

This plant was built for the Government during World War II to produce 500,000 tons annually by the Modified Bayer process. Sintering facilities for "red mud" processing were also installed there. The plant was leased by Kaiser in 1946 and purchased in 1949 subject to a modified National Security Clause. Equipment to use the modified Bayer process has been installed. The plant operates primarily on Jamaican ore from company-owned deposits. The plant has grown gradually since its construction.

Gramercy, Louisiana

Gramercy is a fairly new plant, beginning operation in 1959. It has experienced more rapid growth in recent years than has the Baton Rouge plant. Like the Baton Rouge plant, this plant operates on Jamaican ore and uses the Modified Bayer process also.

c. Martin Marietta Aluminum, Inc.

St. Croix, Virgin Islands

Martin Marietta's plant which was completed in 1967 is the newest bauxite plant in the U.S. or its possessions. To the best of our knowledge, this plant operates on purchased bauxite from Guyana and Australia. It uses the Modified Bayer process. Martin Marietta is participating in a joint venture for a bauxite mine in West Guinea.

d. Ormet Corporation

Burnside, Louisiana

Ormet's plant is another young bauxite plant. Its capacity has grown steadily since 1964. Ormet does not have its own bauxite supply and, therefore, buys Surinam bauxite. The method used here is the conventional Bayer process.

e. Reynolds Metals Company

Corpus Christi, Texas

This plant, built during 1952-54, adjoins the company's San Patricio primary reduction plant. Originally designed to operate on straight Jamaican bauxite, it employs a modification of the Bayer process. It, like Alcoa's Point Comfort, Texas plant, has also experienced a very rapid growth and is now the largest bauxite refining plant in the U.S. The same reasons apply here as at Point Comfort, that is, the bauxite sources are company-owned mines in Jamaica and Haiti and the alumina plant is located near a company-owned primary reduction plant in Texas and is on the Gulf Coast.

Hurricane Creek, Arkansas

This plant was built for the Government and operated by Alcoa during World War II. Production began in July 1942. After operating the facilities under lease for three years, Reynolds purchased the plant in 1949, subject to a modified National Security Clause. The plant employs the Combination process on locally-mined ore. It uses a small amount of imported bauxite from company-owned operations in Guyana to bring the silica content of the overall ore within practicable processing tolerances. Similar to Alcoa's Bauxite, Arkansas plant, it has experienced very little growth due to its heavy reliance on limited domestic reserves. Also, like Alcoa's plant, it produces only about 15 percent of its alumina for eventual use in the production of aluminum metal. It has over 300 customers and produces more than 30 different products.

Each alumina plant, in our opinion, is utilizing the best known technology available for the particular ore it is processing. Efficiencies range from 70 to 90 percent recovery of the alumina from the bauxite depending on the difficulty of the ore.

Plant sizes in terms of both employment and annual production of alumina are shown in Table II-4. All U.S. plants are about the same size. One reason for this is that the minimum economic size for an alumina plant today appears to be about 330,000 tons per year (1,000 tons per day) of alumina, assuming 90 percent utilization. Another reason is that once a plant reaches about 500,000 tons per year, increases in economy with size are not as great since plants larger than this usually consist of two parallel lines under the same roof. In such cases, some economies of scale would be experienced because of such things as shared infrastructure, townsite, dock facilities, overhead, etc. But, requirements per ton of alumina for such things as raw materials, power, and labor begin to level out.

3. Segmentation

Because of the concentrated nature of the domestic bauxite refining industry, we plan to assess the economic impact of water pollution guidelines on a plant by plant basis. This approach allows for a more specific analysis of each plant's possible problems rather than a generalized analysis of a particular segment.

A significant question arises in the segmentation of an industry; what criteria should be used? One approach which seems right to one person may not sound best to another. Also, a plant or firm may fall into a "gray" area where it is difficult to tell which segment it fits into.

Fortunately, the domestic bauxite refining industry consists of only five companies and nine plants which permits the individual analysis of each plant and, therefore, by-passes potential problems presented by the segmentation scheme. It should be noted that this industry is very unique in this respect and that this particular method of analysis may be very difficult and time consuming in most other major industries.

C. FINANCIAL PROFILES*

As discussed earlier, we are concerned with the performance of five companies. These are Alcoa, Kaiser, Reynolds, Martin Marietta Aluminum, and Ormet. The first three are among the four largest aluminum producers in the world and are known as the "Big 3" in the U.S. Martin Marietta Aluminum, formerly Harvey Aluminum, is part of the large conglomerate firm Martin Marietta Corporation. Ormet is owned 50% by Olin Corporation and 50% by Revere Copper and Brass, Inc. The financial profiles of these companies will be presented herein.

In respect to Ormet Corporation, the discussion of Revere will be emphasized since Olin has recently announced its intention to divest itself of its interests in Ormet. We are, therefore, presently studying the financial arrangements related to Olin's announced intention to divest itself of its interests in Ormet and in view of the obligations of Olin in respect to Ormet and Revere, as presented later. For the moment, we associate Ormet's operations and alumina facility primarily with Revere Copper and Brass and have grouped it under Revere because of this transient ownership situation.

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*Information contained herein was obtained from the individual company's 10-K report filed with the SEC in March, 1973.

Selected financial data and highlights of the operations of the "Big 3" are presented in Tables II-5 through II-7. Details of current operations will be presented subsequently.

1. Aluminum Company of America

Alcoa is the largest aluminum company in the world. Alcoa has probably the firmest raw material base, with large reserves in Jamaica, Surinam, Australia, and (still under development) Guinea, West Africa. The company also has limited U.S. reserves, but most of its current raw material requirements are met by importing bauxite to supply domestic alumina plants. Over 80% of the company's smelter capacity is located in the United States.

Bauxite and Alumina

The company mines bauxite from properties which it owns in Arkansas, and from reserves held under mining rights in Surinam (expire 2033), the Dominican Republic (expire 2007, subject to renewal under conditions contained in the concession agreement) and Jamaica (expire 1982 and 1993, subject to renewals under conditions prescribed in the mining laws of Jamaica). The company estimates that the bauxite contained in such properties and reserves is sufficient in the aggregate to supply its requirements for bauxite, at current consumption rates, for a period of at least 40 years.

In Western Australia, the company has certain mineral rights and also has options to acquire additional mineral rights. The present mineral rights of the company currently supply bauxite sufficient to produce 7% of the alumina required to operate the company's present domestic primary aluminum capacity. The company can increase this supply to 42% of such requirement by exercising, in five increments, such options to acquire additional mineral rights. However, the exercise of any such option after December 30, 1986, is subject to the approval of the government of Western Australia. All such mineral rights are held subject to a mineral lease which expires in 1982 but may be extended, at the option of a 51% owned subsidiary of the company, to 2045. All bauxite from such mineral rights is to be refined at an alumina plant or plants in Australia owned or to be owned by such sibsidiary. The right to refine bauxite from the present mineral rights expires in 1988 but may be extended by the

TABLE II-5

REFERENCE DATA ON MAJOR PRIMARY ALUMINUM PRODUCERS

	Alcoa	Kaiser	Reynolds
Percent Change in Earnings			
Due to Aluminum price change	high	med. - high	high
Reported Income Tax Rate			
1971	32%	31%	nil
1970	40%	31%	32%
Estimated Breakdown of Revenue			
Primary	10 - 15%	5 - 10%	23 - 27%
Fabrication	65 - 70%	60 - 70%	62 - 66%
Other Sales	10 - 15%	5 - 10%	10 - 12%
All Other, n.e.c.	5%	23 - 29%	-
	100%	100%	100%

NOTE: While reasonable care was taken in compiling this data and presenting it in as consistent a fashion as is possible, we cannot guarantee absolute comparability from one company to the next, due to differences in the nature of earnings, and differences in their accounting for certain balance sheet and income statement items. To the best of our knowledge the above data present an accurate and meaningful basis for selective comparisons.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

TABLE II-6

FINANCIAL PERFORMANCE DATA ON MAJOR PRIMARY ALUMINUM PRODUCERS

Company	Net Sales for the Year	Operating Income before Depreciation	Net After-Tax Earnings (before Extraordinary Items)	Capital Expenditures	Operating Ratio: Op. Income ÷ Sales	Net After-Tax Return on Stockholder's Equity	Ratio of Capital Expenditures to Gross Plant at Year End
	$ million				Percent		
Alcoa							
1971	1,441.2	251.2	55.30	199.4			
1970	1,522.4	323.5	114.30	284.9			
1969	1,545.2	330.8	122.40	247.3			
1968	1,352.8	308.7	104.70	177.2			
					av. 20.7%	av. 8.8%	av. 8.6%
Reynolds							
1971	1,093.2	114.6	5.89	79.7			
1970	1,035.2	171.3	47.46	112.7			
1969	1,012.7	173.3	57.07	128.6			
1968	843.8	121.5	31.09	127.4			
					av. 14.8%	av. 7.3%	av. 7.1%
Kaiser							
1971	904.5	104.2	27.00	107.4 Includes			
1970	880.9	122.3	50.80	121.6 Avg. of			
1969	925.8	148.9	60.20	158.1 $37.6/yr.			
1968	850.1	138.2	52.00	132.8 Investments			
					av. 14.5%	av. 9.0%	av. 9.7%

NOTE: While reasonable care was taken in compiling this data and presenting it in as consistent a fashion as is possible, we cannot guarantee absolute comparibility from one company to the next, due to differences in the nature of earnings, and differences in their accounting for certain balance sheet and income statement items. To the best of our knowledge the above data present an accurate and meaningful basis for selective comparisons.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

TABLE II-7

SELECTED FINANCIAL DATA: MAJOR U.S. ALUMINUM COMPANIES

1971	Alcoa	Kaiser Aluminum	Reynolds
Sales (in millions of dollars)	1,462.1[a]	904.5	1,106.5[a]
Pre-Tax Profit (in millions of dollars)	76.7	39.2	5.5
Net Income (in millions of dollars)	52.0	27.0	5.9[b]
Cash Flow from Operations and Holdings (in millions of dollars)	187.9	69.0	72.9
Increase (Decrease) in debt	71.5	85.9	70.3
Dividends Paid	41.2		18.0
Current Ratio: Assets/Liabilities	3.2	1.6	3.2
Net Working Capital	520.0	189.0	408.0
Capital Expenditures	199.4		79.7
Long-Term Debt, year end	954.0	589.0	878.0[c]
Equity, year end	1,268.6	631.6	699.1
Debt ÷ (debt and equity) Percent based on book values	43.0	48.1	55.5
Scheduled Debt Repayment (1972 payment excluded from long-term debt at year end 1971)			
1972	21.9	35.9	50.4
1973	40.3	31.7	64.1
1974	28.0	31.3	52.7
1975	42.0	33.1	66.7
1976	36.3	53.1	92.9
Long-Term Financing (in millions of dollars, 1971)	203.9	123.1	122.0
Employment, year end	44,064	24,500[d]	35,900

a. Includes other revenues and/or income, as reported.
b. $47.5 for 1970.
c. Includes $125.0 of convertible debentures.
d. Estimated.

TABLE II-7 Cont'd.

NOTE: While reasonable care was taken in compiling this data and presenting it in as consistent a fashion as is possible, we cannot guarantee absolute comparability from one company to the next, due to differences in the nature of earnings, and differences in their accounting for certain balance sheet and income statement items. To the best of our knowledge the above data present an accurate and meaningful basis for selective comparison.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

company to 2008. Upon exercise of any option to acquire additional mineral rights, the right to refine the related bauxite has a basic 20-year term, which may be extended by the company for an additional 20 years.

Alcoa also has alumina plants in Jamaica, Surinam, and Australia. It has a substantial planned surplus of alumina capacity over its own needs, which has allowed it to sign a number of long-term supply contracts.

Alcoa has a 27% interest in Halco (Mining), Inc., the company formed as a consortium to develop the extensive Boke-bauxite deposits in Guinea. (Martin Marietta has a 20% participation--as will be discussed.) By 1980, this will be supplying about one-third of Alcoa's demand. Alcoa is also constructing a $125 million alumina plant in Costa Rica, which may supply 15% of its needs at that time.

Primary Aluminum

Most of the bauxite and alumina produced by Alcoa is used for further processing by the company into aluminum. Most of the primary aluminum produced is further processed into fabricated products which generally are sold to producers of consumer and industrial products in various industries. The total production of primary aluminum by the company during 1972, including all primary aluminum produced by nonconsolidated subsidiaries and affiliates, constituted approximately 15% of the free world's estimated primary aluminum production.

Primary aluminum is produced from alumina at smelting plants at Alcoa, Tennessee; Badin, North Carolina; Evansville, Indiana; Massena, New York; Point Comfort, Texas; Rockdale, Texas; Vancouver, Washington; Wenatchee, Washington; and Surinam. The company's primary aluminum capacity at December 31, 1972, including one-half of the capacity of two smelters in Norway in which the company holds 50% interests, was 1,725,500 short tons and its primary aluminum production during 1972 was 1,392,000 short tons. Capacity is based on normal operating conditions and does not represent maximum possible production. Primary aluminum shipments by Alcoa during 1972 were 388,000 short tons. Fabricated aluminum products are produced at 26 domestic and 3 foreign plants owned by the company. The annual capacity of fabricating facilities is dependent upon the product mix. Shipments by the company of fabricated aluminum products were 1,178,000 short tons in 1972.

In response to the effects of over-capacity in the world aluminum industry, Alcoa has stated it reduced primary aluminum production so that in 1972 the company's average operating rate was 87.1% of the capacity of its domestic smelters. In the latter part of 1972 and early 1973, as demand increased sharply, certain primary aluminum production units were started up. The company's domestic primary aluminum operating rate on February 28, 1973 was 93.5%.

Alcoa Smelting Process

Alcoa has applied for patents on the "Alcoa Smelting Process," a new electrolytic method of producing primary aluminum from aluminum chloride, made from alumina, which it expects will reduce by as much as 30% the electricity required by the most efficient units of the Hall process (presently used worldwide in the production of primary aluminum) and result in lower operating costs. The new process, which involves electrolysis in a completely enclosed system, is expected to be essentially free of undesirable emissions and to afford a superior employee working environment. Moreover, the new process is reportedly more tolerant of power interruptions than the Hall process and will permit plants to be located on smaller sites, with greater location flexibility. The new process does not involve the need for fluoride chemicals, as does the Hall process, and thereby eliminates the expenses of containing fluoride emissions.

The company has reportedly spent $25 million in the development of the new process, which has been tested in a full scale developmental unit. The first unit of an Alcoa Smelting Process plant, having an initial capacity of 15,000 tons per year of primary aluminum and an ultimate design capacity of 30,000 tons, is expected to be completed in 1975. Completion of the entire plant, presently conceived as a 300,000-ton facility, is contingent upon construction and operating experience with the first unit. The company does not expect that the new process will result in any near-term obsolescense of its existing facilities for smelting aluminum.

Other Business

In addition to being the largest integrated producer of primary aluminum and fabricated aluminum products, Alcoa's operations also include the sale of engineering and construction services, shipping and the fabrication of products from other metals.

Under the management of Alcoa Properties, Inc.--a wholly owned non-consolidated subsidiary--the company acquires and develops land, develops and operates real estate properties, sells developed land and properties and constructs and sells residential properties, including housing for low and middle income families. Such operations in real estate, housing and land development are closely coordinated with the company's operations in the manufacture and marketing of building products, components and systems combining a variety of materials. The latter operations are conducted by a division, Alcoa Building Industries.

A recent important policy change is Alcoa's willingness to sell technical assistance (although the first sale was to Anaconda, hardly a newcomer to the industry). Alcoa has decided that technical assistance is now available from so many sources that it might as well take advantage of the profit opportunity represented by its own considerable expertise.

Consolidated Income

Table II-8 presents Alcoa's consolidated income statements for the last five years. Alcoa reported that income from operations for 1971 was adversely affected by lower shipments, price weaknesses, increased depreciation and interest expense, and June 1, 1971, labor contracts resulting in higher operating costs. During 1972, shipments increased but the other factors continued to affect adversely the company's income from operations.

Net income for 1972 increased substantially over that for 1971, approximately $29 million of such increase resulting from the sale of the company's interest in three real estate developments. There were no substantial real estate development sales during 1968 or 1971, but two large properties were sold during each of the years 1969 and 1970.

Alcoa's cash flow from operations, including the effects of deferred credits and reserves and equity in non-consolidated entities, was $238MM in 1972, compared to $188MM for 1971.

Assets

Alcoa's consolidated balance sheet as of December 31, 1972, showed total assets of $2.704 billion. Current assets were $804 million, current liabilities $240 million, providing $564 million in net working capital. Total properties, plant, and equipment at cost was $3.033 billion, almost twice 1972 sales; net property, plant and equipment, after accumulated depreciation depletion and amortization, was $1.495 billion.

Long-Term Debt

Table II-9 summarizes Alcoa's outstanding long-term debt at December 31, 1972. Long-term debt due after one year was $904 million. Deferred items were $221 million including $197 million in deferred tax reserves. Equity consisted of $66 million in preferred stock and $1,119 million in common stock and retained earnings.

Alcoa is somewhat unique in that while it has a significant amount of long-term debt, it has a relatively low debt-equity ratio among the aluminum companies. It appears to be consistent with this financial position that its debt is in the form of debentures and notes instead of first mortgage bonds.

TABLE II-8

ALCOA AND CONSOLIDATED SUBSIDIARIES

STATEMENT OF CONSOLIDATED INCOME

	1968	1969	1970	1971	1972
			$Millions		
Income:					
Sales & Operating Revenues	1352.8	1545.2	1522.4	1441.2	1753.0
Interest, principally from entities not consolidated	8.6	10.3	13.1	12.7	12.1
Other Income	8.9	13.3	7.3	8.2	13.8
	1370.3	1568.8	1542.8	1462.1	1778.9
Costs & Expenses:					
Cost of goods sold & operating expenses, not including depreciation & depletion	882.3	1039.5	1022.5	1011.7	1269.8
Selling, gen'l admin. & other expenses	135.3	144.9	148.3	149.2	154.9
Provision for depreciation & depletion	113.0	121.9	127.8	137.5	150.9
Interest Expense	32.8	36.9	48.6	57.8	61.4
Taxes, not including social security & U.S. and foreign taxes on income	26.5	30.0	28.1	29.2	30.4
	1189.9	1373.2	1375.3	1385.4	1667.4
Income before U.S. & foreign taxes on income	180.4	195.6	167.4	76.7	111.5
Provision for U.S. & foreign taxes on income:					
U.S.:					
Current	52.4	49.8	27.3	(17.0)	7.7
Future	7.7	13.3	15.1	15.2	8.2
Foreign:					
Current	15.8	22.0	24.0	27.2	27.7
Future	4.2	2.8	.3	(.7)	(1.0)
	80.1	87.9	66.7	24.7	42.6
Income from Operations	100.3	107.7	100.7	52.0	68.9
Equity in earnings (losses) of entities not consolidated:					
Real Estate Developments	(1.3)	6.0	4.4	(5.2)	19.9
Other	5.7	8.6	9.2	8.5	14.0
	4.4	14.6	13.6	3.3	33.9
Income before Extraordinary Items	104.7	122.4	114.3	55.3	102.8
Extraordinary Items	--	--	(18.8)	--	--
Net Income	104.7	122.4	95.5	55.3	102.8

SOURCE: Aluminum Company of America, Form 10-K annual report.

BLE 9

ALUMINUM COMPANY OF AMERICA

LONG-TERM OBLIGATIONS

(December 31, 1972)

(In thousands of dollars)

	Due						Total long-term debt
	1973	1974	1975	1976	1977	1978-96	
Sinking fund debentures:							
3% due 1979..........	--	--	$ 4,071	$ 4,150	$ 4,150	$ 8,700	$ 21,071
4 1/4% due in 1982....	--	$ 1,471	5,200	5,200	5,200	26,200	43,271
3 7/8% due in 1983....	--	3,032	5,200	5,200	5,200	31,400	50,032
6% due 1992..........	--	--	7,000	7,000	7,000	104,000	125,000
9% due 1995..........	--	--	--	--	--	150,000	150,000
7.45% due 1996........	--	--	--	--	--	150,000	150,000
Notes:							
3% due 1973..........	$12,000	--	--	--	--	--	12,000
4 3/8% due 1988.......	1,243	3,250	3,250	3,250	3,250	35,821	50,064
4.65% due 1989........	2,699	5,200	5,200	5,200	5,200	82,608	106,107
6% due 1977-89........	2,205	2,247	2,296	2,352	2,416	35,311	46,827
5 1/4% Convertible Subordinated debentures due 1991	--	--	--	--	6,250	118,750	125,000
6 1/2% bonds due 1986...	--	--	--	--	--	20,048	20,048
Other.................	9,276	3,930	10,014	4,061	801	3,642	31,724
	$27,423	$19,130	$42,231	$36,413	$39,467	$766,480	$931,144
Less amount due within one year included in current liabilities........................							27,423
Noncurrent long-term debt..							$903,721

2. Kaiser Aluminum & Chemical Corporation

Kaiser Aluminum & Chemical Corporation is the third largest domestic producer of primary aluminum and fabricated aluminum products. Its aluminum operations include the mining of bauxite, the production of alumina from bauxite, the reduction of alumina to aluminum and the fabrication of aluminum and aluminum alloys into a variety of products. Kaiser Aluminum also has substantial interests in enterprises engaged in various aspects of the aluminum business in Africa, Asia, Australia, Canada, Europe, Jamaica and South America.

In addition, it produces agricultural chemicals, certain industrial chemicals, strontium products and a wide range of refractories materials, mines and sells iron ore, engages in real estate activities, engages in international commodity trading, and has interests in nickel and shipping activities. The company is more diversified than the other major aluminum companies. It in turn is controlled by the diversified Kaiser Industries Corporation, which also controls Kaiser Steel and Kaiser Cement. Financial data on Kaiser's business are presented in Table II-10.

Bauxite and Alumina

Kaiser Aluminum mines bauxite from its reserves on the north coast of Jamaica. The Jamaica bauxite is refined into alumina at Kaiser Aluminum's two alumina plants located at Baton Rouge and Gramercy (near New Orleans), Louisiana. The Jamaica reserves are estimated to be sufficient for at least 40 years' capacity operations of the Louisiana alumina plants.

Kaiser depends on Jamaica and Australia for its bauxite, while its alumina plants are located in the United States, Jamaica, and Australia, and a new plant is projected for France. The domestic alumina plants feed most of the company's domestic smelter requirements; thus, raw material imports are primarily in the form of bauxite. The company's greatest bauxite strength lies in Comalco, its Australian operation which is 45% owned by Conzinc Rio Tinto of Australia and 10% by the public. Kaiser has adequate alumina capacity to cover the needs of its smelters.

Primary Aluminum

Kaiser Aluminum owns and operates four domestic aluminum reduction plants with an aggregate rated capacity of 710,000 annual tons of primary aluminum. These plants, at which alumina is reduced to primary aluminum, are located at Chalmette (near New Orleans), Louisiana; Ravenswood, West Virginia; and Mead (near Spokane) and Tacoma, Washington. As of December 31, 1972, these plants were operating at approximately 93% of rated capacity as compared with an operating rate of about 82% in early

TABLE II-10

KAISER ALUMINUM AND CHEMICAL CORP.

FINANCIAL DATA

SUMMARY: NET SALES & INCOME (1)

	1972	1971
	(Expressed in Thousands)	
NET SALES		
Aluminum	$714,423	$663,677
Agricultural Chemicals	90,240	82,860
Refractories	72,057	62,497
Industrial Chemicals	52,591	48,647
Trading	36,410	27,524
Nickel	16,006	4,181
Strontium	588	284
Other	8,514	14,861
Total	$990,829	$904,531
INCOME BEFORE INCOME TAXES AND INTEREST EXPENSE (2)		
Aluminum	$ 47,518	$ 77,636
Agricultural Chemicals	1,306	(25)
Refractories	11,157	5,750
Industrial Chemicals	9,336	2,998
Trading	5,825	4,625
Nickel	(5,125)	(827)
Strontium	(3,223)	(98)
Real Estate	5,322	4,213
Shipping	(1,760)	(1,073)
Other	(1,953)	(13,264) (3)
Total	$ 68,403	$ 79,935
INCOME TAXES AND INTEREST EXPENSE	53,340	52,934
NET INCOME BEFORE EXTRAORDINARY ITEMS	$ 15,063	$ 27,001

(1) Aluminum, Industrial Chemicals, and Trading are somewhat interdependent, sharing certain facilities and transferring significant quantities of products from one to the other.

(2) Corporate overhead has been allocated on the basis of assets and net sales.

(3) Includes $8,917 loss from modular building operation.

1972, and 88% in early 1971. During 1971 and 1972, Kaiser Aluminum's production of primary aluminum from these four plants was approximately 14.5% and 16%, respectively, of the primary aluminum output in the United States. One of Kaiser Aluminum's two 26,000 annual ton potlines not operating at year-end 1972 at its Mead, Washington, plant was activated on March 1, 1973, and the last inactive line is scheduled to be activated in early May, at which time Kaiser Aluminum will be operating its primary aluminum production facilities at 100% of rated domestic capacity.

Kaiser Aluminum fabricates a wide variety of aluminum products at fabricating plants located near its Ravenswood and Mead aluminum plants and in principal marketing areas of the United States. Most of the fabricating plants are owned and the remainder are held under long-term leases. Kaiser Aluminum also leases facilities at various locations in the United States for processing and distributing specialized aluminum products. In 1972 and 1971, fabricated products accounted for approximately 68% of the tonnage sales volume of the aluminum business of Kaiser Aluminum.

Long-Term Debt

All of the major United States plants owned by Kaiser Aluminum and the capital stock of the subsidiary which owns Kaiser Aluminum's Jamaica north coast bauxite facilities are subject to the lien of the Indenture of Mortgage and Deed of Trust securing Kaiser Aluminum's First Mortgage Bonds.

The First Mortgage Bond Indenture, as supplemented, restricts borrowings, acquisition of the Corporation's stock, investments, and payment of cash dividends. At December 31, 1972 and 1971, consolidated retained earnings of $27 million and $24 million, respectively, were not restricted as to the payment of cash dividends on preferred, preference, and common stocks under the most restrictive provision of the indenture. Substantially all of the Corporation's domestic plant properties now owned or to be acquired are subject to the first mortgage bond lien, and the capital stock of Kaiser Bauxite Company (wholly-owned subsidiary) is pledged as collateral for the bonds.

A summary of Kaiser Aluminum's long-term obligations at December 31, 1972 are shown in Table II-11.

3. Martin Marietta Aluminum, Inc. (MMA)

Martin Marietta Aluminum, Inc., formerly Harvey Aluminum, is an 82.7%-owned subsidiary of Martin Marietta Corporation. MMA's operations shown in the perspective of Martin Marietta Corporation are presented in Table II-12.

TABLE II-11

KAISER ALUMINUM & CHEMICAL CORPORATION

LONG-TERM OBLIGATIONS

(December 31, 1972)

	(In thousands of dollars)						
	Due						
	1973	1974	1975	1976	1977	1978-96	Total
First Mortgage Bonds:							
3.625% due 1976...........	$ 2,425	$ 2,425	$ 2,425	$22,850	$	$	$ 30,125
4.93% due 1976............	1,625	1,625	1,625	1,375			6,250
3.75% due 1976............	2,500	2,500	2,500	2,500			10,000
4.25% due 1981............	4,800	4,800	4,800	4,800	4,800	33,600	57,600
5.56% due 1981............	1,200	1,200	1,200	1,200	1,200	5,600	11,600
5.50% due 1987............	1,600	1,600	1,600	1,600	1,600	26,000	34,000
5.375% due 1991...........	1,920	1,920	1,920	1,920	1,920	38,880	48,480
6.875% due 1993...........	--	3,000	3,000	3,000	3,000	48,000	60,000
8.625% due 1993...........	--	--	2,750	2,750	5,500	89,000	100,000
5.25% due 1994............	3,200	3,200	3,200	3,200	3,200	74,400	90,400
6.25% due 1996............	1,700	1,700	1,700	1,700	1,700	39,800	48,300
5% Subordinated Guaranteed Sinking Fund Debentures of a subsidiary..........						30,000	30,000
Capitalized Building Lease Obligation...............						21,788	21,788
Swiss Franc Notes of a subsidiary-7%..............					21,517		21,517
Other Domestic Borrowings (3% to 7.4%).............	2,709	2,519	2,218	1,898	1,904	6,348	17,596
Other Foreign Borrowings (6.3% to 11%)...,........	7,893	5,217	5,373	5,710	2,146	2,501	28,840
Total................	$31,572	$31,706	$34,311	$54,503	$48,487	$415,917	$616,496
Less amount due within one year							31,572
Long-term Obligations......							$584,924

TABLE II-12

MARTIN MARIETTA CORP.

Business Category		Net Sales			Earnings	
	1972	% Total	1971	1972	% Total	1971
		-------------$ Millions---------------				
Cement	114.8	11%	122.1	20.0	18%	17.3
Aggregates	99.0	10%	90.0	16.9	15%	14.0
Chemicals	84.0	8%	71.1	24.7	23%	18.8
Aerospace	545.5	52%	469.0	32.4	30%	38.5
*MMA	203.6	19%	206.7	10.6	10%	9.6
Total	$1,046.8		$958.8	$104.6		$98.2
Add: Investments & Other				+ 4.5		+10.5
Earnings bef. interest & taxes				109.1		108.7
Deduct: Interest				- 22.4		-17.6
Taxes on Income				- 32.9		-37.4
Minority Interest				- 0.3		- 0.5
Net Earnings				$ 53.5		$53.2

MMA has a smelter at the Dalles, Oregon (90,000 tons) and at Goldendale, Washington (104,000 tons/year). The bulk of sales are channeled through its large rolling mill at Lewisport, Kentucky. MMA has an extrusion facility in Torrance, California, primarily producing specialized shapes for the aerospace-defense industry on the West Coast, but increasingly in commercial markets.

The company has completed an alumina refinery at St. Croix, V.I., which has enough capacity to supply MMA's two smelters in the Pacific Northwest. The bauxite for MMA's operations is coming from the Boke-deposits in Guinea, W. Africa, as a result of a consortium--Halco (Mining) Inc.--formed by several aluminum companies with the Republic of Guinea to develop these high quality deposits. MMA has a 20% participation in Halco. MMA's investment to date in Halco is $6.8 MM ($4.6 MM net).

Most of MMA's aluminum was transferred to its own mills for fabrication, whereas in previous years much of its requirement for primary metal was purchased from others. The increase in productive capacity of primary metal will have greater significance for earnings in years when aluminum ingot prices are at a more normal level.

At the Company's rolling mill at Lewisport, Kentucky, where capacity has been increased within recent years, conversion costs have been reduced. The mill is well located in relation to its markets, and its 1972 production was above the previous year. At year's end the Lewisport mill was running at capacity. The Company feels that demand for sheet and plate is exceptionally strong throughout the industry; capacity limits of the industry are being pressed and delivery lead times are well extended. MMA states "Most indicators seem to point to further price imporvements in these product areas."

The Boke bauxite project, the alumina refinery at St. Croix, the two smelters in the Northwest, and the rolling mill at Lewisport, Kentucky, taken together, represent approximately 94% of the book value of the Company's fixed assets.

The investments made in recent years in the aforementioned facilities, and the resulting increase in primary metal capacity have shifted the center of gravity of the company away from its older facilities at Torrance, California. These latter facilities were oriented originally toward the defense market but their operating results have for some time penalized total company earnings.

Accordingly, both the facilities and the product lines have been the subject of intensive analyses from which certain conclusions were reached in 1972 and are being implemented in 1973.

Capital expenditures at Torrance have been restricted and, in 1972, the company withdrew from the aluminum foil business and decided to no longer participate in the automatic screw machine business. Both of these product areas had been unprofitable. The latter business was almost entirely defense oriented and, in fact, most of the facilities are old and are government owned.

Early this year MMA decided to serve its West Coast customers for sheet and plate producers from the Lewisport plant to the extent that it will be practicable to do so. This step will eliminate a small sheet mill at Torrance that has resulted in losses. Also, MMA decided to withdraw from the soft alloy extrusion business on the West Coast. The company states this activity had been unprofitable in competition with many small specialized extruders who use large quantities of scrap and are able to operate such a business in a more cost-competitive manner.

Long-Term Debt

MMA's long-term debt is approximately $150 MM--representing about 47% of the sum of debt plus equity, and almost half of the parent company's long-term debt. Interest charges were about $14 million in 1972 (before interest capitalization on funds used in construction), and debt maturities (principal) for 1973 are a similar amount. Details are shown in Table II-13.

4. Revere Copper and Brass, Inc.

American Smelting and Refining Company, "Asarco," owned of record 33% of the common stock of Revere outstanding December 31, 1972, and 41% of the outstanding 5-1/2% convertible debentures due 1992.

Revere's principal business is the production and sale of nonferrous metal products in three product classes: (1) mill products; (2) primary aluminum; and (3) utensils and other products.

Mill Products

Revere produces and sells a full line of nonferrous metal products in copper, aluminum and many alloys. Principal markets for the Company's brass mill products are automotive, building and construction, electrical, air conditioning and refrigeration, appliances, defense and component parts such as screw machine products, forgings, stampings and other products.

TABLE II-13

MARTIN MARIETTA ALUMINUM, INC.

LONG-TERM OBLIGATIONS

	December 31, 1972		December, 31, 1971	
	Current Portion	Noncurrent Portion	Current Portion	Noncurrent Portion
Bank loans at 5 1/2% 5 1/2%	$ --	$ --	$ 6,750,000	$ --
Revolving bank loans (1)	--	--	53,000,000	--
Bank term loans (1)	12,000,000	48,000,000	--	--
Economic Development Administration Loan (2)	--	10,000,000	--	10,000,000
9 3/8% Sinking Fund Debentures (3)	--	50,000,000	--	50,000,000
Industrial Revenue Bonds, Lewisport (4)	1,730,000	39,435,000	1,640,000	41,165,000
Other notes and contracts	217,932	553,533	360,632	4,558,327
	$13,947,932	$147,988,533	$61,750,632	$105,723,327

(1) The revolving bank loans of $53,000,000, bearing interest at 1/2% in excess of the prime rate, were repaid on December 27, 1972 with the proceeds of the $60,000,000 bank term loans, which are due in quarterly installments of $3,000,000 beginning March 31, 1973 to December 31, 1977, and bear interest at 1/2% in excess of the prime rate (currently 6%).

(2) The loan obtained from the United States Economic Development Administration in June 1971 bears interest at 4 3/4% and is collateralized by a mortgage on the Company's Washington reduction plant. The loan is payable only as to interest for five years and in quarterly installments of $193,860, including interest, for 20 years thereafter.

(3) The 9 3/8% Sinking Fund Debentures, issued June 15, 1971, are due June 15, 1971, are due June 15, 1996. The Company is required to retire $2,500,000 of debentures annually beginning in 1977.

(4) Lewisport bonds payable represent the outstanding amount of the industrial Revenue Bond issue under the agreements referred to in Note C.

In aluminum, the Company produces and sells an extensive line of mill products including plates, coils, flat sheets, circles, blanks, foil, extruded shapes, tubes and pipes in a wide range of specifications and finishes. The principal markets for the Company's aluminum mill products are consumer durable goods, construction, containers, transportation, packaging, and electrical. Aluminum mill products are also used in the Company's own fabricating operations; for example, aluminum sheet is supplied to the Company's wholly-owned subsidiary, Revere Aluminum Building Products, Inc., where it is processed into aluminum siding and accessories.

Brass and aluminum mill products are sold directly by the Company to the using industries. Sales offices of the Company operate in 24 cities in the United States. Both types of mill products also are sold through specialty distributors, such as plumbing distributors. Consigned and warehouse stocks and redistribution centers are maintained throughout the country in strategic cities.

Bauxite and Aluminum

Revere Jamaica Alumina Ltd., a wholly-owned subsidiary of the Company, has a bauxite mining operation and a 220,000-ton capacity alumina plant located in southwestern Jamaica, W.I. Substantially all of the investment in plant and equipment of the subsidiary is covered for risks of war and expropriation under a contract of guaranty in effect with the Overseas Private Investment Corporation (an Agency of the United States Government).

Revere Jamaica Alumina, Ltd., holds a bauxite mining lease from the Government of Jamaica, for 25 years with a guarantee of extension for a further 15 years.

Primary Aluminum

The principal markets for the Company's primary aluminum are extruders, wire mills, foundries, and secondary smelters. Primary aluminum ingot is sold directly to the using industries and through one major distributor. It is estimated Revere presently handles about 195,000 tons aluminum metal per year--120,000 tons from its own reduction plant at Scottsboro, Alabama; and 75,000 tons as its share of Ormet Corporation's production (see below). Thus, it is not a major aluminum producer.

Primary aluminum for the Company's aluminum mill products and for sales to customers is acquired from the Company's primary aluminum reduction plant in Scottsboro, from Ormet Corporation (50% of the stock of which is owned by the Company), from other primary producers, and by melting and casting primary aluminum and aluminum scrap at the Company's mills. Alumina for the Scottsboro reduction plant is obtained chiefly from Revere Jamaica Alumina, Ltd.

Other Products

Utensil products are sold under the Revere Ware trademark to department stores, independent housewares and hardware distributors, chains, premium firms and catalog houses. Utensil product lines include copper clad stainless steel, stainless steel with carbon steel cores and aluminum utensils with Teflon coatings and a varied line of tea kettles. Utensil plants are in Illinois, Alabama, and New York.

Other metal products include eyelets, stampings, lockseam tubing, welded steel tubing, lead and tin foil, zinc engravers' plates, aluminum building products and electrical switches and wiring devices. These are generally sold through distributors.

Sales by product classes and total sales during the past five years, excluding certain transfers to other Company plants, are set out in Table II-14 in millions of dollars together with the percentage of total sales by each product class.

Table II-15 presents a consolidated summary of Revere's operations for 1968-1972.

Ormet Corporation (and Ormet Shipping, Olin Revere Realty Company)

Revere and Olin Corporation each own 50% of the stock of Ormet Corporation, a corporation engaged in the production of primary aluminum, and have invested additional sums in notes of Ormet. The three companies have entered into an agreement which provides that (1) Revere and Olin will purchase 34% and 66%, respectively, of all aluminum produced by Ormet and will pay as the price of such aluminum 34% and 66%, respectively, of Ormet's annual costs. The annual costs, which are to include depreciation and amortization in amounts not less than Ormet's bond maturities, are payable even if no aluminum is produced. Such debt maturities to be included in costs billed to Revere aggregate $2.0MM for 1973, $2.7MM each year from 1974 through 1977 and $2.1MM in 1978. (2) Revere and Olin will advance to Ormet 34% and 66%, respectively, or any amounts required for capital replacements and maintenance of working capital at a prescribed level. (3) As long as any of Ormet's bonds are outstanding, Olin has the option to purchase 32% of Revere's interest in Ormet at a price equal to Revere's cost. The Company carries its investment in Ormet at cost which amount equals its equity because Ormet's pricing policy for aluminum sales, as described above, results in its operation producing neither gains or losses.

TABLE II-14

REVERE COPPER AND BRASS, INC.

SALES BY PRODUCT CLASS

(millions of dollars)

Year	Sales of Mill Products		Sales of Primary Aluminum		Sales of Utensils and Other Products		Total Sales
1968	$276.1	81.2%	$32.8	9.6%	$31.3	9.2%	$340.2
1969	301.3	82.9%	34.2	9.4%	27.8	7.7%	363.3
1970	278.4	84.8%	23.7	7.2%	26.2	8.0%	328.3
1971	289.7	86.5%	18.3	5.5%	27.0	8.0%	335.0
1972	320.4	82.0%	34.9	8.9%	35.6	9.1%	390.9

TABLE II-15

REVERE COPPER AND BRASS, INC.
CONSOLIDATED SUMMARY OF OPERATIONS

(millions of dollars)

	1972	1971	1970	1969	1968
Net Sales	$390.9	$335.0	$328.0	$363.0	$340.0
Cost of Sales	351.9	305.0			
Depreciation & Depletion	12.7	6.9			
G&A	20.3	19.0			
Interest Expense	9.2	2.5			
Interest and Other Income	2.0	1.7			
Income Tax Before Investment Tax Credit	0.5	1.09	4.0	11.11	12.40
Investment Tax Credit		(1.45)	(4.80)	(.86)	(5.20)
	0.5	(.35)	(.80)	10.25	7.20
Income (loss) Before Extraordinary Charge	(9.44)	3.62	9.09	12.13	16.79
Extraordinary Charge		1.75			
Net Income (loss)	(9.44)	1.87	9.09	12.13	16.79

Revere and Olin also own 50%, respectively, of the stock of Ormet Shipping Corporation, which owns and operates three bauxite carrying vessels under charter with Ormet Corporation. The Company's investment in Ormet Shipping Corporation is carried at cost, which amount equals its equity. Revere and Olin are partners in Olin Revere Realty Company, a firm which acquires and leases new plant facilities to Ormet. The Company's 50% investment in Olin Revere Realty Company is carried at equity.

In November 1972, Olin announced its intention of disposing of all of its aluminum assets, which include large domestic aluminum fabricating plants and its investment in Ormet, on a "going concern" basis. Under the agreement between Olin and Revere pursuant to which Ormet was organized, Revere has the right of first refusal in connection with any sale by Olin of its interest in Ormet. Revere's management does not foresee any adverse effects on Revere's investment in Ormet, Olin Revere Realty or Ormet Shipping Corporation as a result of the disposal by Olin of its aluminum facilities.

Long-Term Debt

Lease obligations - Construction of the aluminum rolling mill and the aluminum reduction plant at Scottsboro, Alabama, was financed by industrial revenue bonds issued by the Industrial Development Board of Scottsboro in 1965 ($60MM), and 1967 ($97MM). The plants are leased to the Company under leases which expire in 1987 and 1990, respectively, at rentals sufficient to pay the interest and principal retirement requirements of the bond issues. The Company has the right to purchase the rolling mill from July 1975, and the reduction plant from December 1977, until termination of the respective leases, for an amount in each instance sufficient to redeem all outstanding bonds of the applicable issue. For accounting and tax purposes the projects are treated as constructed and owned by the Company. There are three similar revenue bond issues totaling $6.5MM for plant facilities at Newport, Arkansas; Monett, Missouri; and Anderson County, South Carolina. Retirement requirements to be included in rent payments aggregate about $5 million per year over the next five years.

The $55 million proceeds of the 5-1/2% Convertible Subordinated Debentures due 1992 sold in 1967 were used to partially finance the development of bauxite mining facilities and construction of the alumina plant in Jamaica.

5. Reynolds Metals Company

Reynolds Metals Company is the second largest U.S. producer of primary aluminum and manufactures aluminum products for a broad variety of industries.

Reynolds' rated annual domestic primary aluminum capacity of 975,000 tons was approximately 20.4% of the reported total rated domestic capacity of 4,771,000 tons as of December 31, 1972.

Reynolds distributes its industrial-related products principally through direct sales from its manufacturing plants to converters, fabricators, and distributors, and its consumer-related products principally through sales to wholesale and retail distributors.

Net sales for the five years ended December 31, 1972, are presented in Table II-16.

The net income after taxes for Reynolds was only $0.19MM in 1972, compared to $5.6MM in 1971 and $46.9MM in 1970. Included in these was equity in income to subsidiaries and associated companies of $40.4MM in 1972, $37.4MM in 1971, and $50.5MM in 1970--each larger than Reynolds' pre-tax income in the respective years, indicating the poor results of Reynolds' domestic aluminum business.

Looking at the consolidated statements, the overall pre-tax income was $5.1MM deficit in 1972, $5.5MM in 1971, and $69.5MM in 1970. In the consolidated statements, the equity in income of unconsolidated subsidiaries and associated companies added only $7MM in 1970, $3.9MM in 1971, and $5.5MM in 1972; however, the latter was still large compared to 1972 net results.

Properties

Reynolds mines bauxite in Jamaica, Arkansas, Haiti and Guyana. It produces alumina at Hurricane Creek, Arkansas; Corpus Christi, Texas; and Nain, Jamaica. Reynolds Jamaica Alumina, Ltd., a wholly-owned subsidiary of Reynolds, formed a partnership, Alumina Partners of Jamaica, with Anaconda Jamaica, Inc., a wholly-owned subsidiary of The Anaconda Company and Kaiser Jamaica Corporation, a wholly-owned subsidiary of Kaiser Aluminum and Chemical Corporation, under the laws of the State of Delaware, for the processing of bauxite into alumina at Nain, Jamaica. Primary aluminum is produced at Listerhill, Alabama; Longview, Washington; Jones Mills and Arkadelphia, Arkansas; Troutdale, Oregon; Corpus Christi, Texas; Massena, New York; and Baie Comeau, Canada. Primary aluminum production for Reynolds in 1972 was 938,501 short tons.

Additionally, Reynolds' proportionate share in primary aluminum capacity of foreign companies (other than Canadian Reynolds Metals Company Limited) in which it has varying degrees of interest is 121,700 tons.

Long-Term Debt

Reynolds owns all of its principal plants and machinery except that part of the land and buildings of certain can plants held under a long-

TABLE II-16

REYNOLDS METALS COMPANY

NET SALES

	Primary Aluminum (1) Tons (2)	Primary Aluminum (1) Amounts	Aluminum Fabricated Products	Other Sales	Total Net Sales
		(In Millions of Dollars)			
1968	304.6	$143.1	$613.8	$ 86.9	$ 843.8
1969 (2)	474.3	232.9	683.0	96.7	1,012.7
1970	495.2	255.2	664.6	115.3	1,035.2
1971	376.2	185.5	759.1	148.6	1,093.2
1972	357.0	164.2	863.3	134.7	1,162.2

(1) Includes small quantities of secondary aluminum.

(2) Includes Canadian Reynolds Metals Company, Ltd. from 1969.

term lease. Substantially all the land, buildings and equipment of the Reynolds Metals Company in the United States are subject to the lien of the mortgage securing its First Mortgage Bonds.

Reynolds' property additions and retirements are shown in Table II-17. Reynolds has built up a very high debt-to-equity ratio and this, combined with the extremely high capital intensity of the primary aluminum business, provides enormous financial leverage in Reynolds' financial outlook. A very small change in the operating rate or cost or price of aluminum will be magnified in the resulting changes in Reynolds' earnings and profitability.

Table II-7 presents the recent cash flow (net income plus depreciation and other noncash charges against reported earnings) picture for Reynolds.

6. Capital Availability

As is widely appreciated, the aluminum industry is probably one of the most, if not the most, capital intensive major manufacturing industries in the world. Tables II-6 and II-7 and details which have been discussed herein demonstrate that the capital expenditure programs of the "Big 3" have been massive, as have their long-term financing. In general, aluminum properties have been financed largely with long-term mortgages secured by their assets. The companies have benefited in the early days from various forms of government financial assistance (both domestically and internationally); more recently in the U.S. community industrial revenue bond financing has been utilized by these companies.

Aluminum companies typically have relatively high debt-to-equity ratios. The companies thus are highly leveraged financially and, depending on the particular circumstances, may or may not be in a position to attract any additional capital at any given moment.

D. PRICE EFFECTS

1. Determination of Prices

It is very difficult to determine a market price for either bauxite or alumina since nearly all sales of both are made internally to company-owned plants and, therefore, are not readily available on the open market. This situation, in the case of alumina availability, has begun to change recently for a number of reasons. One of these is the fact that economies

TABLE II-17

REYNOLDS METALS COMPANY
PROPERTY ADDITIONS AND RETIREMENTS

(In Thousands of Dollars)

Year	Additions	Retirements	Net Additions
1968	$127,372	$14,330	$113,042
1969	128,600	13,765	114,835
1970	112,670	13,183	99,487
1971	79,319	10,736	68,583
1972	70,079	11,913	58,166
Total	$518,040	$63,927	$454,113

of scale require alumina plants to be very large in order to be competitive, and this has led to the need to form worldwide consortia to exploit new bauxite deposits and produce alumina. The participation of different aluminum producers and of other interests besides aluminum producers in alumina investments has led to a greater readiness on the part of alumina plants to sell their product under long-term contracts to non-participants in the venture.

The two Arkansas plants produce a variety of products each with its own market price which tends to make price determination even more complicated. For this reason, we will limit our discussion of price determination to alumina which is produced for the eventual use in the production of aluminum metal. This one use accounts for about 80-85 percent of the alumina produced domestically.

a. Alumina Availability

There is little opportunity to spot-purchase alumina on the world market, and in those instances where spot purchases are made, the prices paid are usually substantially higher than those paid on long-term contracts. One of the reasons why there are few spot sales of alumina is the fact the alumina producers usually invest in additional alumina capacity only when they are assured of long-term market outlets through either captive requirements or long-term contractual sales. They do not invest in alumina capacity with the expectation of simply trying to sell the product on the world market. Since up to now the major aluminum producers have controlled most of the alumina production capacity, this policy has allowed them to maintain a reasonable balance between worldwide alumina demand and supply. This situation may change as more and more private investment interests participate in alumina plants built throughout the world.

Besides the major integrated aluminum producers in the Western World, the only other significant potential suppliers of large quantities of alumina on a long-term basis are the state-owned companies of the Socialist countries. Since arrangements for the purchase of alumina from the countries will be made through government-to-government agreements, we do not know, nor can we find out, the sales policies of these countries in regard to alumina. We do know that some alumina is traded among Socialist countries in Eastern Europe and that the Soviet Union currently imports some alumina from the Western World countries to supplement its own supplies.

Also, in some cases where raw materials are transferred between companies, barter agreements are made whereby the buyer of the raw material, either bauxite or alumina, pays the seller in the form of a refined product, either alumina or aluminum. Therefore, no purchase prices are quoted in the transaction.

b. Price Trends

However, from what information is available, some estimates can be made. In the early 1960's, most intercompany sales of alumina f.o.b. Caribbean ports were in the range of \$45-50/short ton. These prices rose to \$50-55/short ton in the later 1960's and contracts in 1969-70 are closer to \$60-65/short ton f.o.b. alumina plant. The f.o.b cost of alumina from other plants in the Western World processing indigenous bauxite using a Bayer process is in general similar to these prices. One of the major factors responsible for the increase in the intercompany prices of alumina during this period was the fact that alumina prices are usually related to posted aluminum metal prices through an escalation clause in the contract. For example, the current posted price of aluminum in the United States is in the range of 33¢/lb. whereas the price in the early 1960's was in the range of 23¢/lb. The price history of primary aluminum since 1930 is shown in Figure II-6. In addition, the construction costs for industrial plants have increased considerably over the past ten years.

c. Import Data

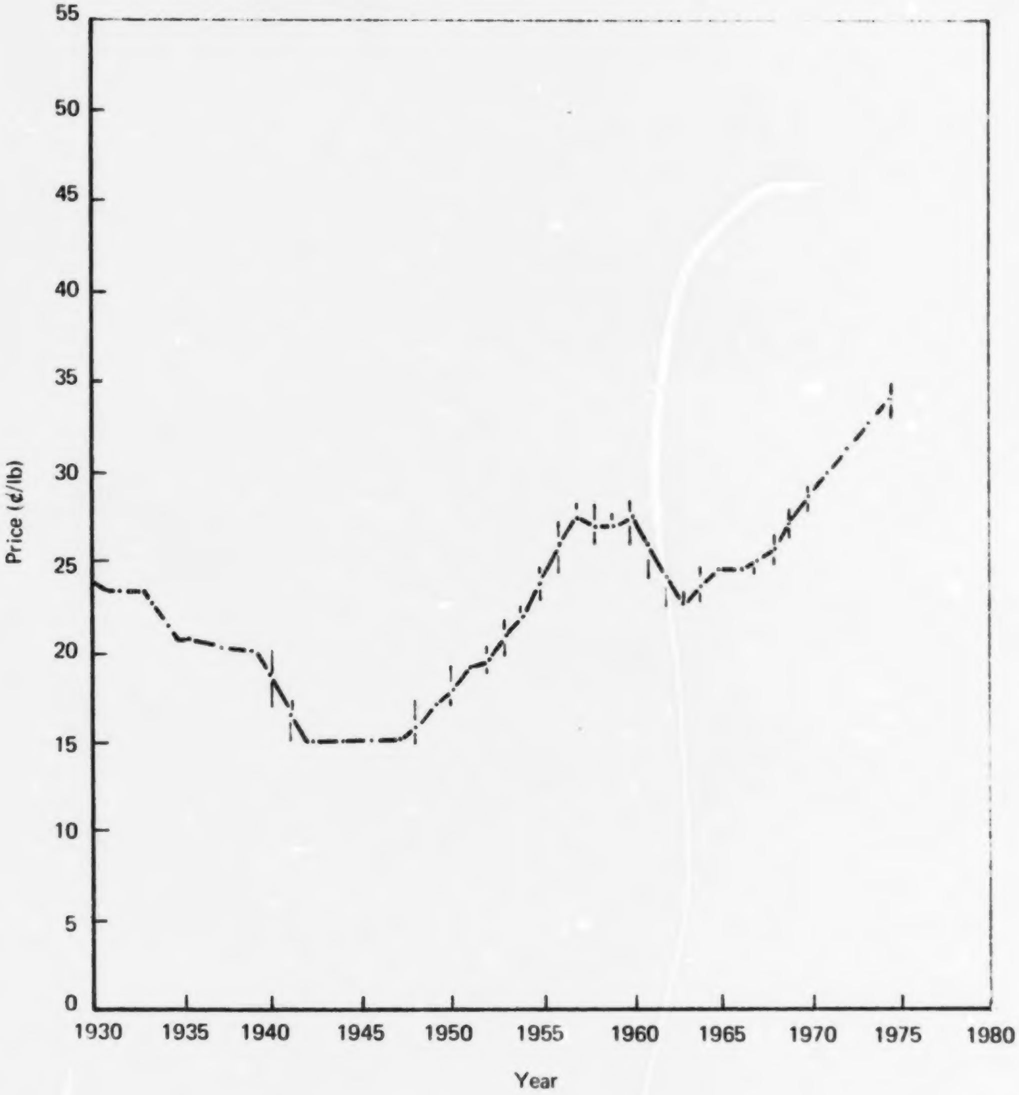
A source of information for determining the market price for alumina and bauxite is the U.S. import data. According to this data, the f.o.b. values of bauxite and alumina imported into the U.S. in 1971 averaged \$12.46 per long ton (\$11.13 per short ton) and \$58.07 per short ton, respectively. The import data for bauxite over a ten year period are shown in Table II-18. Similar data for alumina are presented in Table II-19, although the U.S. has only been importing alumina since 1965. There is a fairly wide range in values for imported bauxite and alumina depending on the country of origin (see Tables II-20 and II-21). Therefore, various raw material costs and varying transportation costs will result for the different domestic bauxite refining plants since each relies on its individual bauxite sources.

d. Domestic Production of Bauxite

Table II-22 shows the domestic mine production of bauxite and the f.o.b. value in dollars per short ton for a ten year period. Also shown are similar data for Arkansas mine production of bauxite. The Arkansas values are considered to be the most accurate representation of the f.o.b. cost of domestic bauxite to an alumina plant since 90 percent of the domestic bauxite production and essentially all of the domestic supply for alumina production in 1971 came from Arkansas mines.

2. Costs of Production

The product values presented earlier are actual market values and reflect only the relative actual costs. Actual costs for bauxite are needed to



SOURCE: Metals Week List Prices

FIGURE II-6 PRICE HISTORY OF PRIMARY ALUMINUM

TABLE II-18

U.S. IMPORTS FOR CONSUMPTION OF BAUXITE

Year	Quantity (Thousand Long Tons)	Total Value (Thousand Dollars)	Average Value f.o.b. (Dollars/Long Ton)
1962	10,575	121,888	11.53
1963	9,212	114,546	12.43
1964	10,180	128,787	12.65
1965	11,199	142,989	12.77
1966	11,529	147,335	12.78
1967	11,594	151,418	13.06
1968	10,976	140,228	12.78
1969	12,160	165,639	13.62
1970	12,620	156,362	12.39
1971	12,326	153,639	12.46
Totals	112,371	1,422,831	12.66

SOURCE: Minerals Yearbook

TABLE II-19

U.S. IMPORTS OF ALUMINA FOR USE IN PRODUCING ALUMINUM

Year	Quantity (Thousand Short Tons)	Total Value (Thousand Dollars)	Average Value f.o.b. (Dollars/Short Ton)
1965	227	13,527	59.59
1966	489	27,383	56.00
1967	952	50,173	52.70
1968	1,317	73,295	55.65
1969	1,912	106,333	55.61
1970	2,555	152,537	59.70
1971	2,391	138,841	58.07
Totals	9,843	562,089	57.11

SOURCE: Minerals Yearbook

TABLE II-20

AVERAGE VALUE OF U.S. IMPORTS OF BAUXITE, 1971

Country	Average Value, Port of Shipment (Dollars/Long Ton)
Australia	10.68
Brazil	8.57
Dominican Republic	16.58
Greece	8.41
Guinea	4.93
Guyana	11.20
Haiti	9.86
Jamaica	12.76
Surinam	11.12

SOURCE: Minerals Yearbook Preprint, 1971

TABLE II-21

AVERAGE VALUE OF U.S. IMPORTS OF ALUMINA FOR USE IN PRODUCING ALUMINUM, 1971

Country	Average Value, Port of Shipment (Dollars/Short Ton)
Australia	53.69
France	57.01
Germany, West	98.00
Greece	62.71
Guyana	71.46
Jamaica	66.99
Japan	72.32
Surinam	58.00

SOURCE: Minerals Yearbook Preprint, 1971

TABLE II-22

DOMESTIC MINE PRODUCTION OF BAUXITE

Year	Quantities (Thousand Long Tons)		Total Value (Thousand Dollars)		Average Value f.o.b. (Dollars/Long Ton)	
	Arkansas	Total U.S.	Arkansas	Total U.S.	Arkansas	Total U.S.
1962	1,270	1,369	14,606	15,609	11.50	11.40
1963	1,478	1,525	16,701	17,234	11.30	11.30
1964	1,562	1,601	17,431	17,875	11.16	11.16
1965	1,593	1,654	17,974	18,632	11.28	11.26
1966	1,718	1,796	19,439	20,095	11.31	11.19
1967	1,571	1,654	18,269	19,079	11.63	11.54
1968	1,582	1,665	23,058	23,752	14.58	14.27
1969	1,755	1,843	24,706	25,725	14.08	13.96
1970(1)	1,869	2,082	26,293	30,070	14.07	14.44
1971	1,781	1,988	24,979	28,543	14.03	14.36

(1) Includes data for Oregon and Washington.

SOURCE: Minerals Yearbook.

develop costs for alumina production since most bauxite is transferred intracompany and is not sold on the open market. A Bayer plant which is dependent on purchased bauxite has an added cost which is equal to the profit taken by the bauxite vendor, all other costs being equal. For this reason, as mentioned earlier, an alumina producer has not been able to grow to an appreciable size without obtaining its own bauxite supply.

Table II-23 presents the production costs for typical Bayer plants of various sizes located in the Gulf Coast area. Trihydrate (gibbsite) material averaging about 53% Al_2O_3 and 3% silica is processed utilizing the American Bayer process. One ton of alumina is produced for every 2.1 tons of bauxite consumed. This represents a recovery of about 90 percent.

The bauxite cost is our approximate estimate of the cost to a Bayer plant from a company-owned mine. This involves mining, crushing, drying, transportation and handling costs.

Bayer plants which must process different types of ores or must purchase their ores or have varying transportation distances will, as a result, have a different set of criteria for calculating their production costs for alumina. A $1.00 change in the cost of bauxite will change the cost of alumina by slightly more than $2.00 as seen from Table II-23.

We expect that the cost of producing both bauxite and alumina will continue to increase in the future as it becomes necessary to process lower grades of bauxite ore, as plant construction costs continue to rise leading to higher capital charges, and as labor costs increase. In addition, the Bayer process is being utilized at so close to its theoretical efficiency limit that we do not expect any major technological improvements in the process in the near future. At the same time, we believe that product prices will continue upward, thus, offsetting any normal increases in cost.

3. Purchase Contracts

Most alumina bought on the open market is in large amounts and on long-term contracts. Contracts for annual supplies over 100,000 short tons of alumina per year are for a long-term period,typically ranging from 10 to 20 years. Contracts for smaller quantities of alumina are made but usually for shorter periods.

Bauxite ore can also be sold in this manner, but this case is much more rare than the alumina sales contract. Almost all alumina producers have captive bauxite sources. This is one requirement mentioned earlier for sustained growth as an integrated aluminum producer.

TABLE II-23

GENERAL PRODUCTION COSTS FOR ALUMINA (TRIHYDRATE)
($/Short Ton Al_2O_3)

Item	Units	Units per Ton/Al_2O_3	$/Unit	Plant Size (S. Tons/Year) 200,000	500,000	1,000,000
Materials						
Bauxite	S. Tons	2.1	10.00	21.00	21.00	21.00
Caustic Soda	S. Tons	0.08	53.00	4.20	4.20	4.20
Lime	S. Tons	0.06	20.00	1.20	1.20	1.20
Utilities						
Fuel for calcination and steam	MMBTU	9.4	.25	2.40	2.40	2.40
Electric power	KWH	330	.004	1.30	1.30	1.30
Materials and Supplies (operating and maintenance)				3.00	3.00	3.00
Labor @ $4.20/hour				15.80	9.20	6.20
Plant Overhead (50% of labor)				7.90	4.60	3.10
Total Direct Costs (excluding depreciation, taxes, insurance, interests, profits)				56.80	46.90	42.40
Estimated Fixed Charges in Addition (at 14% of capital investment)				33.60	26.60	23.50

SOURCE: ADL Estimates.

There are wide variations in the terms of alumina purchase contracts, and every new contract tends to be slightly different from previous ones. The final contractual terms in most cases depend largely on the negotiating skill and imagination of the purchaser and seller. There are, however, some generalizations that can be made on these contracts.

Most contracts are for f.o.b. sales, although some producers are interested in c.i.f. sales because of their interest in the shipping contract. Alcoa, in particular, which has very large shipping interests, has considerable interest in c.i.f. sales contracts.

Practically all contracts contain an escalation clause that relates the sales price of alumina either to an agreed-upon posted price of aluminum metal or to cost indices related to the production cost of alumina. The cost indices used in the past have included fuel costs, secondary raw material costs, interest rates, and sometimes a general wholesale price index. In some cases, the sales price of alumina is related to a combination of metal prices and cost indices according to a specified formula.

Although cash payment is usually specified for purchases of alumina, some contracts provide for barter arrangements. In these contracts, the purchaser usually pays the seller in supplier of metal at a specified exchange rate. This arrangement allows the buyer of alumina to eliminate the selling expense associated with a percentage of his total production. This expense may run from 1¢ to 3¢ per lb. of metal depending on the discounts made or credit advanced to customers. Also this arrangement allows the alumina buyer, who is producing aluminum, to operate his facility at a higher output since he has a guaranteed market for the increased production. This results in a savings to him since his operation is more efficient as his production level approaches full capacity.

Most contracts are take-or-pay agreements. This means that the purchaser must take a given quantity of alumina at specified periods, or else he must pay an agreed-upon penalty usually equal to the value of the alumina.

Most contracts contain a "force majeure" clause. Under this clause, neither the seller nor the buyer is in breach of contract if he cannot deliver or accept supplies of alumina due to events beyond his control such as strikes, fire, explosion, war, blockade, etc.

Since there are no industry-wide quality standards for alumina, contracts usually simply specify impurity levels. The impurities specified usually include SiO_2, Fe_2O_3, TiO_2, and Na_2O. The maximum moisture content is also usually specified. In addition to the above, the physical characteristics of the alumina are specified including a screen analysis of the material.

In most cases, the buyer must specify his requirements 6 to 12 months in advance of delivery. He must also supply the seller with a shipping schedule at least 4 to 6 months before the first delivery on this schedule.

In order to show the details of a specific typical purchase contract, we have presented in the Appendix a copy of an expired contract for the sale of approximately 54,000 short tons of alumina per year over a period of ten years. One clause which appears in this contract but is not found in more recent contracts is the requirement that the buyer put up a sizable portion of the purchase price as an advance payment. (See Article 21 in the contract in the Appendix).

4. Effect of Pollution Control Costs on Prices

The ultimate effect of pollution control costs on aluminum prices depends on whether or not these costs are evenly distributed across the industry. If they are, the major deterrent to any price increase is the competitive situation of aluminum with other materials and products such as iron and copper. If the costs are not evenly distributed, then those plants or segments of the industry which are harder hit will not be able to pass on the increased costs because of the internal competition within the industry.

Plants which cannot pass on the costs would have to absorb them. If the increased costs can neither be passed on nor absorbed, the probability of the plant shutting down is almost certain unless the costs can be absorbed by other segments of the corporation or unless the plant can marginally survive until the market price of aluminum goes up.

E. ASSESSMENT OF ECONOMIC IMPACT

The analysis for each level of control technology will be presented separately. Within each level the economic impact of water pollution guidelines on the domestic bauxite refining industry will be assessed on a plant-by-plant basis. This method of approach will permit a fairly detailed analysis of each plant's possible problem areas, if any.

In assessing the overall economic impact for each level, we will focus on such things as price increases, plant closings, unemployment, community impacts, industry growth, and balance of payments.

F. IMPACT ANALYSIS

This study assesses only that economic impact due to water pollution guidelines. It does not consider costs due to compliance with air pollution guidelines. However, a cursory examination shows that the bauxite refining industry has a very minimal, if any, air pollution problem.

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Development Document for the bauxite refining industry. These guidelines are:

1. Best Practicable Control Technology (BPT) - to be met by industrial dischargers by 1977.
2. Best Available Control Technology (BAT) - to be met by 1983.
3. New Source Performance Standards (NSPS) - to be applied to all new facilities (that discharge directly to navigable waters) constructed after the promulgation of these guidelines (June 3, 1974).

The guidelines for all three levels of control established by the Environmental Protection Agency (EPA) for bauxite refining plants require that "there shall be no discharge of process waste water pollutants to navigable waters." However, the Federal Register (April 8, 1974) provides the following exception to this requirement:

> During any calendar month there may be discharged from the overflow of a process waste water impoundment either a volume of process waste water equal to the difference between the precipitation for that month that falls within the impoundment and the evaporation within the impoundment for that month, or, if greater, a volume of process waste water equal to the difference between the mean precipitation for that month that falls within the impoundment and the mean evaporation for that month as established by the National Climatic Center, National Oceanic and Atmospheric Administation, for the area in which such impoundment is located (or as otherwise determined if no monthly data have been established by the National Climatic Center).

There is some question as to how this quantity of water would be measured, i.e., on a daily basis or at the end of the month. It would not be feasible to impound all the rainwater until the end of the month when the allowable discharge could be calculated. Also, there are no water quality limitations on that volume of water permitted for discharge. This water would be excess rainwater landing in the mud lakes and would obviously become contaminated with process water.

1. Industry Segmentation

For purposes of the economic impact analysis, we have divided the bauxite refining industry into three segments or groups:

- No Cost
- Moderate Cost
- High Cost

The following criteria were used for placing the plants in the various groups:

No Cost - the plant will have negligible cost imposed by the proposed effluent guideline.

Moderate Cost - the plant will incur an incremental operating cost of 0.5¢/lb or less of contained aluminum and an additional capital investment of up to 10 percent of the estimated 1973 plant replacement cost.

High Cost - the plant's additional operating cost will be 0.5¢/lb of contained aluminum or greater and the added capital investment will be 10 percent of the estimated 1973 plant replacement cost or greater.

2. Estimated Replacement Costs

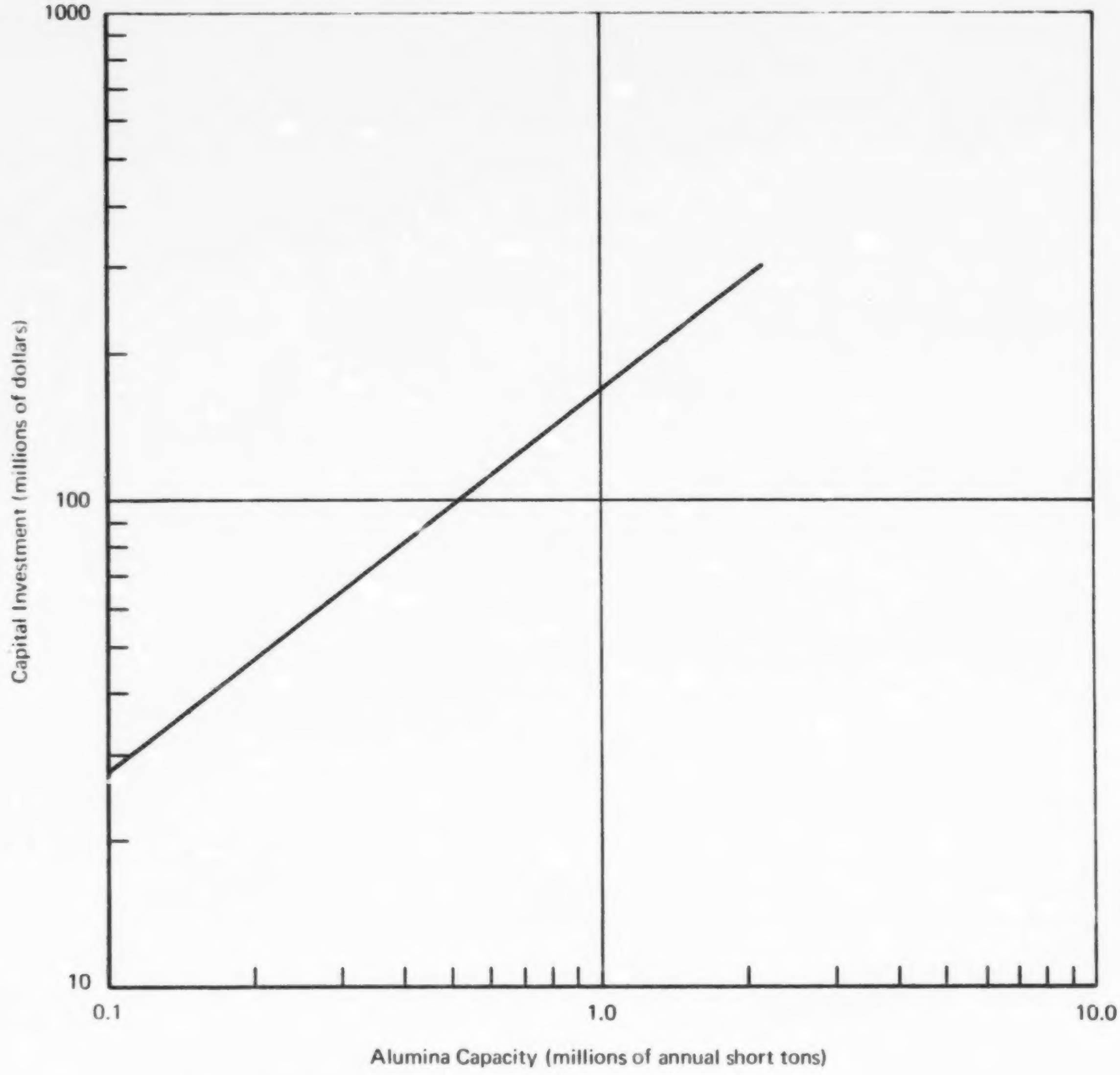
Figure II-7 presents a plot of estimated 1973 capital investment vs. capacity for Bayer alumina plants. These estimated investments are only for the plants themselves and do not include investment in infrastructure facilities, land, docks, and wharves. It also does not include settling ponds or other techniques for dealing with the production plant residues and effluent wastewater.

The existing Bayer plants range in size from 375,000 to 1,460,000 short tons of alumina per year, representing replacement costs of about $77 million to $225 million per plant, respectively.

3. Basis for Analysis

In the following analysis, we discuss the possible impact of the effluent guidelines from the following viewpoints:

- Price effects and plant shut down probabilities
- Financial effects - corporate impact
- Production effects
- Balance of payments
- Employment and community effects



Source: Arthur D. Little, Inc., estimates

FIGURE II–7 U.S. BAYER PLANTS – ESTIMATES OF CAPITAL INVESTMENT VERSUS CAPACITY – 1973

In general, the capital and operating costs to achieve pollution abatement would not be incurred by the companies in the absence of pollution abatement regulations, i.e., they cannot be justified on the basis of conventional return-on-investment criteria. In plant-by-plant and company-by-company analysis of pollution abatement impact, two viewpoints have to be considered. The availability of capital for pollution abatement equipment at each plant has to be viewed from the standpoint of the resources available to the entire corporation. However, the justification for spending this capital at a particular plant would result from a study of that particular plant's economics which would take into account alternatives such as cost of production from a refitted plant, shifting production to other plants, and most important, the probability that this particular plant will remain a profitable entity.

In an impact analysis, prediction of plant shutdowns is difficult since such a decision is based on a wide variety of factors as noted above. On the other hand, independent analysis of what [illegible] venture or program of expenditures might do to the firm in the [illegible] financial community can be undertaken with more confidence by securities analysts and investment bankers, for there are usually somewhat analogous situations from which to draw inferences and because such inferences can be drawn from data of the kind generally supplied to such individuals and organizations and to the SEC.

In general, we would assume that a large industrial corporation which is clearly viable, profitable, and is acknowledged to have strong managerial and technical resources, will have access to substantial capital--in the form of debt or equity or both, plus pollution control bonds as a source of "off the balance sheet" financing.

In the following approach, the complete impact analysis for each effluent guideline will be discussed before considering the next guideline.

4. Best Practicable Control Technology

As described earlier, the BPT effluent limitation for the bauxite refining industry is no discharge of process waste water pollutants to navigable waters with an exception for excess rainwater.

In addition, EPA has given two plants a variance under the BPT limitation. These two plants are owned by one company and are currently covered under a consent decree between EPA and the company, dated October 13, 1972. Under the terms of the consent decree, the two plants have developed a sand bed filtration system to eliminate the current discharge of red mud while still discharging process waste water from the dewatered red mud.

EPA has agreed that the BPT technology of "total impoundment" for the bauxite refining industry is not consistent with the sand bed filtration system and that no discharge of all process waste water pollutants may not be achievable with the sand bed filtration system. Therefore, in regard to these two plants, the BPT requirement of no discharge of process waste water pollutants will be applied to only those process waste water streams not covered by the consent decree.

Costs of Control

The costs for the industry to meet the BPT effluent guideline of no discharge of waste water pollutants were provided by EPA and are presented in Table II-24. These costs were developed by EPA with the aid of information obtained from the industry. The costs, in general, seem to be reasonable order-of-magnitude costs for the implementation of the regulation. Of course, detailed engineering estimates would need to be made to arrive at more exact costs.

Plants 3 and 6 are the two plants given the variance from the BPT requirements. Plant 3 was under a compliance schedule to meet the consent decree requirements by June, 1974, whereas, plant 6 is to comply by June, 1975. About 80 percent of the costs shown in Table II-24 for these two plants result from the estimated requirements of the consent decree. The remaining portions result from the additional requirements imposed by the BPT effluent limitation.

Segments

Table II-25 presents the estimated investment and operating costs to meet the guideline, summarized by industry segment, while Table II-26 shows the added capital investments as percentages of the estimated replacement costs. It also presents the operating costs in dollars per ton of alumina produced and in cents per pound of contained aluminum. The information presented in Table II-26 is consolidated for each segment to prevent identification of single plants. There is no need to include the "no cost" segment in this table.

Tables II-27 and II-28 give the annual alumina capacity and employment, respectively, for each segment. Also given for each are the percentages of total industry represented by each segment.

Price Effects

Although a large amount of alumina produced in the U.S. is for captive use, a significant amount is sold and the price of alumina is more of an open market price than an internal transfer price. Past history shows that this price is not subject to rapid fluctuations and has gradually increased with increasing operating costs.

Table II-29 presents estimated operating costs for 1972 in dollars per ton of alumina produced for various size Bayer plants and Table II-30 shows average values for 1971 of U.S. imports of alumina for use in producing aluminum. Comparing the cost in Table II-29 for the largest plant ($65.90 per short ton) with the overall average in Table II-30 ($67.52 per short ton) it appears that the average value of alumina today is between $65 and $70 per short ton. A value of $70 is assumed for purposes of this analysis.

TABLE II-24

ESTIMATED INVESTMENT AND OPERATING COSTS FOR BEST PRACTICABLE CONTROL TECHNOLOGY

PLANT NUMBER	CAPITAL INVESTMENT	ANNUAL OPERATING COST*
1.	$ 2,400,000	$ 500,000
2.	1,000,000	210,000
3.	19,280,000	4,616,000
4.	0	0
5.	1,250,000	260,000
6.	32,485,000	7,770,000
7.	200,000	40,000
8.	0	0
9.	0	0
Totals	$56,615,000	$13,396,000

*Includes Depreciation and Interest

SOURCE: Environmental Protection Agency

TABLE II-25

ESTIMATED INVESTMENT AND OPERATING COSTS
FOR BEST PRACTICABLE CONTROL TECHNOLOGY BY INDUSTRY SEGMENT

SEGMENT AND PLANT NUMBER	CAPITAL INVESTMENT	ANNUAL OPERATING COST*
High Cost		
3.	$19,280,000	$ 4,616,000
6.	32,485,000	7,770,000
Sub-totals	$51,765,000	$12,386,000
Moderate Cost		
1.	$2,400,000	$ 500,000
2.	1,000,000	210,000
5.	1,250,000	260,000
7.	200,000	40,000
Sub-totals	$ 4,850,000	$ 1,010,000
No Cost		
4.	--	--
8.	--	--
9.	--	--
Totals	$56,615,000	$13,396,000

*Includes Depreciation and Interest

SOURCE: Environmental Protection Agency

TABLE II-26

RELATED INFORMATION ON COSTS FOR MEETING BEST PRACTICABLE CONTROL TECHNOLOGY

ITEM	HIGH COST SEGMENT	MODERATE COST SEGMENT
Investment as percentage of replacement cost	16	0.8
Annual operating cost ($/ton of alumina)	6.40	0.26
Annual operating cost (¢/lb. of aluminum)	0.6	0.02

SOURCE: ADL Estimates

TABLE II-27

ANNUAL CAPACITY OF ALUMINA AND PERCENT OF TOTAL INDUSTRY REPRESENTED BY EACH SEGMENT, 1973

SEGMENT	ANNUAL CAPACITY (Thousands of Short Tons)	PERCENT OF INDUSTRY
High Cost	1,935	24
Moderate Cost	3,833	48
No Cost	2,235	28
Totals	8,003	100

SOURCE: ADL Estimates

TABLE II-28

EMPLOYMENT AND PERCENT OF TOTAL INDUSTRY FOR EACH SEGMENT, 1973

SEGMENT	EMPLOYMENT	PERCENT OF INDUSTRY
High Cost	1220	18
Moderate Cost	2730	41
No Cost	2705	41
Total;	6655	100

SOURCE: ADL Estimates

TABLE II-29

GENERAL PRODUCTION COSTS FOR ALUMINA (TRIHYDRATE)

($/Short Ton Al_2O_3)

Item	Units	Units per Ton/Al_2O_3	$/Unit	Plant Size (S. Tons/Year) 200,000	500,000	1,000,000
Materials						
Bauxite	S. Tons	2.1	10.00	21.00	21.00	21.00
Caustic Soda	S. Tons	0.08	53.00	4.20	4.20	4.20
Lime	S. Tons	0.06	20.00	1.20	1.20	1.20
Utilities						
Fuel for calcination and steam	MMBTU	9.4	.25	2.40	2.40	2.40
Electric power	KWH	330	.004	1.30	1.30	1.30
Materials and Supplies (operating and maintenance)				3.00	3.00	3.00
Labor @ $4.20/hour				15.80	9.20	6.20
Plant Overhead (50% of labor)				7.90	4.60	3.10
Total Direct Costs (excluding depreciation, taxes, insurance, interests, profits)				56.80	46.90	42.40
Estimated Fixed Charges in Addition (at 14% of capital investment)				33.60	26.60	23.50

Source: ADL Estimates

TABLE II-30

AVERAGE VALUE OF U.S. IMPORTS OF ALUMINA FOR USE IN PRODUCING ALUMINUM, 1971

Country	Average Value, Port of Shipment (Dollars/Short Ton)
Australia	53.69
France	57.01
Germany, West	98.00
Greece	62.71
Guyana	71.46
Jamaica	66.99
Japan	72.32
Surinam	58.00
Average	67.52

SOURCE: Minerals Yearbook Preprint, 1971

The added operating cost of $6.40 per ton of alumina for the high cost group and $0.26 per ton for the moderate cost group is equivalent to increases of 9.1 percent and 0.4 percent, respectively, above the original base value of $70 per ton. The increased cost incurred by the high cost segment is truly significant. A cost increase of this magnitude affecting only 24 percent of the U.S. production capacity cannot be passed on and could be absorbed only with great difficulty. Thus, there is a clear indication of a high impact upon this entire segment.

Any increase in alumina prices would have to be across the entire U.S. bauxite refining industry and would ultimately result in an increase in domestic aluminum metal prices. For example, if the two plants in the high cost segment were to either close or curtail production, one would expect an increase in price in response to this curtailed supply. However, the eventual price increase caused by an event such as this is difficult to estimate. In addition, this price increase would be realized by all the U.S. alumina and aluminum metal producers, thus, still leaving the two plants in the high cost segment at a competitive disadvantage.

The increased cost to the moderate cost segment of $0.26 per ton of alumina could be either passed on or absorbed under normal circumstances. Even if the cost cannot be passed on, the magnitude of this cost is such that there should only be a minimal effect on this group.

Another measure of a company's ability to absorb increased costs is to compare the cost increases per pound of aluminum to the base cost of producing aluminum on the assumption that an integrated company can spread this cost over all components of primary metal productions. The typical margin for the industry is 1-2¢/lb and at most 3¢/lb. Therefore, the increase of 0.6¢/lb for the high cost group would be significant. Again, the moderate cost group would be minimally effected.

Although the increased annual operating cost of 0.6¢/lb of aluminum is less than the normal 1-2¢/lb margin mentioned above, this cost still places these plants in a "gray area" where it would be entirely the management's decision as to whether or not the plants close.

Financial Effects - Corporate Impact

Although plant closings in the high cost segment cannot be predicted with certainty, the shutdown of the high cost segment would result in a major domestic producer losing over 74% of its alumina supply for domestic aluminum production. Unless this producer intends to exit from the aluminum industry, a major readjustment will have to occur. The closing of any plant is a decision based on a wide variety of factors and includes consideration of factors other than just the incremental cost of pollution control. These decisions include comparisons of the cost of production from a refitted plant versus alternatives, such as producing at other domestic or international plants or new locations, purchasing unfinished or semi-finished products for down-stream operations or stopping production altogether. These decisions have to be made on the basis of anticipated future capital and operating expenses and they are particularly difficult for an outsider to predict because they require access to the company's highly sensitive, direct out-of-pocket cost information and full knowledge of the alternatives open to the company's management. In the absence of detailed information on the cost/benefits of the alternative strategies, the judgments on corporate impact have to be necessarily qualitative.

It is probable that this major producer will not exit from the aluminum industry unless forced by circumstances outside its control and, on this basis, one of the following two courses of action is likely:

- Build alumina capacity overseas
- Undertake capital expenditures at the high cost plants, assuming costs can be absorbed by other segments of the corporation.

Qualitative arguments in favor of overseas refineries would be the following and a major constraint would be capital availability.

- Increased efficiencies
- Location near a raw material source - lower transportation costs
- Pressure from foreign governments for forward integration
- Last continental U.S. refinery built in 1959
- Less stringent environmental regulations
- The corporation has major holdings overseas and relocating would not require a new mode of operations

The cost consequences of the second alternative can be assessed in context of the corporation's sources of revenues, earnings, and record of performance. Preliminary indications are that this corporation will be severely affected on this basis. For example, their estimated water pollution related expenditures over the next four years, as a percentage of average rate of capital spending, will be about 16%. This rate of capital expenditure is high, but is, by itself, probably not critical since presumably pollution bond financing could be utilized. Much more serious is that the added annual operating costs are 15-18% of the corporation's base pretax operating income.

In light of the fact that the company has already incurred the majority of the pollution control costs needed to meet the consent decree requirements at these two plants, it is not probable that the plants will close as a result of the incremental costs added by the BPT requirement.

Other Effects

As discussed above, the two plants, and thus, the parent company will face a substantial economic burden in meeting the BPT requirements but not to the extent of plant closures. For this reason there will be no resultant effects due to the BPT requirement on such things as production, balance of payments, and employment in the U.S. bauxite refining industry.

5. Best Available Control Technology

The effluent limitation for BAT is identical to that for BPT, i.e., no discharge of process waste water pollutants to navigable waters. Also, an exception is given for the discharge of excess rainwater. The two plants previously excluded from the BPT requirement are not excluded from the BAT requirement.

Costs of Control

The capital and operating costs for the industry to meet the effluent limitation of no discharge required by BAT were estimated by EPA with the aid of information obtained from the industry. These costs are presented in Table II-31. As with the BPT costs, the BAT costs seem to be reasonable order-of-magnitude estimates and are sufficient to make the types of judgment needed here.

The costs differ from the BPT costs only for plants 3 and 6 which comprise the high cost segment of the industry. Therefore, we will avoid redundancy by addressing this portion of the overall analysis to just these two plants since the impact shown in the BPT analysis for the remaining plants will not have changed. Table II-32 shows only those costs for the two plants in the high cost segment.

Table II-33 presents, for the high cost segment, added capital investments as a percentage of the estimated replacement costs and also the increased annual operating costs in dollars per ton of alumina produced and in cents per pound of contained aluminum.

Price Effects

As before, we will assume the average value of alumina today is about $70 per short ton. The added operating cost of $7.80 per ton of alumina for the high cost segment is equivalent to an increase of 11 percent above the original base value of $70 per ton. (It should be noted that these costs are in current dollars and it is assumed that both the base value and the pollution costs are inflated to the same extent in 1983.) A cost increase of this magnitude affecting a minority (only 24 percent) of the U.S. production capacity cannot be passed on in the form of a price increase due to competition within the industry. At the same time, absorbing the increased costs would present a considerable burden to these two plants and the parent company. Thus, there is a high probability of a considerable impact on this entire segment due to the BAT requirement.

As mentioned in the BPT analysis, there may be some price increase across the entire U.S. bauxite refining industry because of secondary effects. However, these secondary effects are difficult to quantify and would require separate studies.

As before with the BPT analysis, relating the cost increase per pound of aluminum to the typical operating margin in the industry gives the same result. An operating cost increase of 0.7¢/lb of aluminum is truly significant compared to the normal operating margin of 1-2¢/lb for the industry.

TABLE II-31

ESTIMATED INVESTMENT AND OPERATING COSTS FOR BEST AVAILABLE CONTROL TECHNOLOGY

PLANT NUMBER	CAPITAL INVESTMENT	ANNUAL OPERATING COST*
1.	$ 2,400,000	$ 500,000
2.	1,000,000	210,000
3.	22,700,000	5,500,000
4.	0	0
5.	1,250,000	260,000
6.	36,500,000	9,600,000
7.	200,000	40,000
8.	0	0
9.	0	0
Totals	$64,050,000	$16,110,000

*Includes Depreciation and Interest

SOURCE: Environmental Protection Agency

TABLE II-32

ESTIMATED INVESTMENT AND OPERATING COSTS
FOR BEST AVAILABLE CONTROL TECHNOLOGY
FOR THE HIGH COST SEGMENT

PLANT NUMBER	CAPITAL INVESTMENT	ANNUAL OPERATING COST*
3.	$22,700,000	$ 5,500,000
6.	36,500,000	9,600,000
Totals	$59,200,000	$15,100,000

*Includes Depreciation and Interest

SOURCE: Environmental Protection Agency

TABLE II-33

RELATED INFORMATION ON COSTS FOR MEETING BEST AVAILABLE CONTROL TECHNOLOGY

ITEM	HIGH COST SEGMENT
Investment as percentage of replacement cost	18
Annual operating cost (\$/ton of alumina)	7.80
Annual operating cost (¢/lb of aluminum)	0.7

SOURCE: ADL Estimates

Financial Effects - Corporate Impact

The same general comments apply here as did in the previous analysis for the BPT effluent limitation. A precise course of action for a particular plant is very difficult for an outsider to predict since it requires a full knowledge of all the alternatives open to a company's management.

There will certainly be a considerable burden on the two plants in the high cost segment and also on the parent company. For example, their estimated water pollution related expenditures over the next four years will be about 17% of their average rate of capital spending. This rate of capital expenditure is high, but is, by itself, probably not critical since presumably pollution bond financing could be utilized. Much more serious is that the added annual operating costs are 19-22% of the corporation's base pretax operating income.

However, given that this requirement does not have to be met until 1983, we would assume that suitable technology could be developed to meet the BAT requirement or alternatively, if the decision is to shut down the two plants, a more orderly transition would be possible. Such an orderly transition would imply lower impact on the corporation but a high impact on the employees and perhaps on the U.S. balance of payments and alumina production capacity if the company were to construct new plants overseas. The effects of such an occurrence will be discussed below.

Production Effects

Shown earlier in Table II-27 are the respective annual alumina capacity and the percentage of total production represented by each segment. The result of closing down the high cost segment would be significant in that it represents 24 percent of the domestic production of alumina.

Balance of Payments

All the other plants in the industry are operating at or near rated capacity and would not be able to make up a substantial loss in production. As a result, the closing of the high cost segment would have an initial negative effect on the balance of payments to the extent of $135,450,000, less the value of any bauxite (about $40,000,000) now being purchased overseas. This assumes $70 per ton for the value of alumina and $10 per ton for the delivered value of bauxite.

However, the ultimate effect on the U.S. balance of payments will most probably be something different than the above amount. This is because an increase of about $95.5 million in a foreign alumina supplier's balance of payments might provide this supplier the means with which to buy U.S. produced goods. As a result, the initial balance of payments effect of water pollution controls on the U.S. bauxite refining industry might be reduced.

The estimation of this phenomenon would require a separate study. However, because Caribbean nations appear to increase purchases of U.S. goods with increases in dollar reserves, the balance of payments effect is no worse than about $95.5 million, based on the alumina and bauxite prices shown above.

Employment Effects

Presented earlier in Table II-28 is the employment in each segment and the percentage of total industry represented by each. Closing down the high cost segment would place 1220 workers, or 18 percent of the industry, out of work. Using a multiplier of 2:1, this would affect 2440 other jobs.

6. New Source Performance Standards

The requirement for meeting NSPS for the bauxite refining industry is, as discussed earlier, no discharge of process waste water pollutants to navigable waters. There is an exception for excess rainwater, also discussed earlier.

Costs

There were no cost estimates provided by EPA for the NSPS analysis. Therefore, any statements made with regard to the effects of the NSPS requirement on the construction of new plants within the U.S. must necessarily be qualitative.

Construction of New Plants

A new plant designed with the NSPS effluent limitation in mind could be constructed without much difficulty. However, when considering all factors, it is not likely that a new Bayer plant will be constructed in the continental U.S.; the last was built in 1959. Some of the more important factors influencing the location of Bayer plants in foreign countries near the raw material source are:

- Pressure from foreign governments for forward integration
- Lower transportation costs for raw material
- Less stringent environmental regulations
- Most large aluminum companies have major holdings overseas and building a new plant does not require a new mode of operations.

G. LIMITS OF THE ANALYSIS

1. Accuracy

As mentioned earlier, the costs provided by the EPA are order-of-magnitude costs and in no way can be used as definitive engineering estimates. In using the costs developed by EPA and presented in this study, it must be remembered that these costs are applicable only to the degree of control proposed by the regulations described herein and cannot be construed to apply to any other degree of control.

2. Range of Error

The range of error for costs developed in this manner can at best be within plus-or-minus 30%. In order to obtain more exact estimates, an additional amount of time and money would need to be spent in developing detailed engineering estimates.

3. Critical Assumptions

The major critical assumption made in this analysis was that the costs for compliance with the water pollution regulations would be the only pollution related cost incurred by the integrated bauxite refining-primary aluminum industry. There are several trends in the primary aluminum industry worldwide that would tend to decrease their profit margin and/or lead to an increase in primary metal price. These trends are for increases in the cost of raw materials, labor, electric energy, carbon for electrodes and capital availability. These, plus incremental pollution related costs in other areas such as air pollution control in reduction plants, can cumulatively lead to a more severe impact than described in this report. In addition, the increased price can change the cost advantage offered by aluminum vis-a-vis other competing materials (the cross-elasticity phenomenon), thus affecting the demand for primary aluminum.

4. Questions Remaining to be Answered

There is one major question to be answered: What will be the short range effect of the consent decree on those two plants affected by it? The final terms of the consent decree have not yet been finalized. Therefore, it could conceivably still call for no discharge of process waste water pollutants some time before 1983 (BAT effective date). However, the consent decree allows the plants to appeal to EPA if such a decision were made.

III. SECONDARY ALUMINUM SMELTING AND REFINING INDUSTRY

A. INTRODUCTION

This portion of the study was carried out in conjuction with Charles Licht Engineering Associates, Inc., of Olympia Fields, Illinois. This company is very active in consulting in the secondary aluminum smelting industry.

The purpose of this portion is to supply the Environmental Protection Agency with information regarding the economic impact on the secondary aluminum smelting industry of the costs of pollution abatement requirements under the Federal Water Pollution Control Amendments Act of 1972 for each of the three levels of control:

1. Best Practicable Control Technology (BPT) - to be met by industrial dischargers by 1977.
2. Best Available Control Technology (BAT) - to be met by 1983.
3. New Source Performance Standards (NSPS) - to be applied to all new facilities (that discharge directly to navigable waters) constructed after the promulgation of these guidelines (June 3, 1974).

B. INDUSTRY DESCRIPTION*

Secondary aluminum smelters have been in operation since 1904 with major growth and expansion periods in the 1920's and late 1940's and 1950's. The recovery of aluminum from various forms of aluminum scrap involves four rather distinct operations. These are:

1. Collection, sorting and transporting
2. Presmelting preparation
3. Charging, smelting, and refining
4. Pouring of the product line

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* Much of this chapter is adapted from "Impact of Technology on the Commercial Secondary Aluminum Industry," Donald L. Siebert, U.S. Bureau of Mines IC 8445, 1970.

The last three operations vary somewhat throughout the industry, with resultant variations in water usage and wastewater generation. The following is a description of each operation listed.

1. Collection, Sorting and Transportation

The scrap raw material used by secondary smelters can be divided into two categories, solids and residues. The solids are principally metal and include borings and turnings, new clippings, castings, and forgings, old castings and sheet and irony aluminum. Residues include (1) dross and skimmings from melting operations at foundries, fabricators and the primary aluminum industry and (2) slag formed during secondary smelting operations.

Nearly 95 percent of the secondary smelting raw material containing aluminum is supplied from scrap aluminum purchased from scrap dealers and industrial plants. Classifications and chemical analyses of the scrap have been specified by the Aluminum Smelters Research Institute (ASRI), now the Aluminum Recycling Association. Table III-1 gives the ASRI classification.

A small portion of the secondary scrap supply is gathered by metal collectors, or junk dealers, along with various other metals. These collectors haul loads of mixed metals to scrap dealers, who segregate or sort the scrap into various metals. Most often the dealer will have accounts with various government agencies, aircraft firms, railroads, or other aluminum scrap producers and acquire the metal directly.

The scrap used by the secondary smelters can be divided into five main groups:

1. New clippings, forgings, and other solids
2. Borings and turnings
3. Residues (dross, slag, and skimmings)
4. Old castings and sheet
5. Sweated pig

New clippings, forgings, and other solids originate from manufacturing plants. Borings and turnings are derived mainly from the machining of castings, rods, and forgings by the aircraft and automobile industries. Residues (dross, skimmings, and slag) originate from melting operations at primary reduction plants, secondary smelting operations, casting plants, and other foundries. Old castings and sheet may come from many sources, as automobile parts, household items, and dismantled airplanes. Miscellaneous high iron scrap requires special handling in sweating furnaces.

TABLE III-1

A.S.R.I. ALUMINUM SCRAP CLASSIFICATIONS

1. NEW PURE ALUMINUM CLIPPINGS
2. NEW PURE ALUMINUM WIRE AND CABLE
3. OLD PURE ALUMINUM WIRE AND CABLE
4. SEGREGATED NEW ALUMINUM ALLOY CLIPPINGS
5. MIXED NEW ALUMINUM ALLOY CLIPPINGS
6. MIXED LOW COPPER ALUMINUM ALLOY CLIPPINGS
7. SEGREGATED OLD ALUMINUM ALLOY SHEET
8. MIXED OLD ALLOY SHEET
9. SCRAP SHEET AND SHEET UTENSIL ALUMINUM
10. SEGREGATED NEW ALUMINUM CASTINGS, FORGINGS, AND EXTRUSIONS
11. MIXED NEW ALUMINUM FORGINGS AND EXTRUSIONS
12. MIXED NEW ALUMINUM CASTINGS
13. ALUMINUM AUTO CASTINGS
14. ALUMINUM AIRPLANE CASTINGS
15. MIXED ALUMINUM CASTINGS
16. ALUMINUM PISTONS
17. WRECKED AIRPLANE SHEET AND/OR BREAKAGE ALUMINUM
18. NEW ALUMINUM FOIL
19. OLD ALUMINUM FOIL
20. ALL OTHER ALUMINUM BASE FOILS INCLUDING ETCHED FOIL, RADAR FOIL AND CHAFF
21. SEGREGATED ALUMINUM BORINGS AND TURNINGS
22. MIXED ALUMINUM BORINGS AND TURNINGS
23. SWEATED ALUMINUM
24. ALUMINUM GRINDINGS
25. ALUMINUM DROSSES, SPATTERS, SPILLINGS, SKIMMINGS AND SWEEPINGS
26. ALUMINUM HAIR WIRE
27. ALUMINUM WIRE SCREEN
28. COATED ALUMINUM (PAINTED OR PLASTIC COATED, ETC.)
29. CONTAINERS OF ALL TYPES (OIL, FOOD, BEVERAGE, AEROSOL)
30. ITEMS NOT COVERED SPECIFICALLY BY ABOVE CLASSIFICATIONS

The dealer sorts the collected aluminum scrap into groups of similar composition. Sheet and extruded material are often baled into 3 x 6 ft. bundles. Some dealers briquette borings and turnings for shipment. High iron scrap may be treated by the dealer to concentrate the aluminum or he may ship it directly to the smelter. In treatment, the high iron scrap is heated to above 760°C (1400°F) in a sloping hearth furnace which is direct-fired by natural gas (a "sweating furnace"). The aluminum melts, flows away from the residual iron, and is cast into pigs ("sweated pigs") or sows. In many cases the various types of scrap are shipped loose in large tote boxes.

2. Presmelting Preparation

The presmelting preparation of scrap varies in accordance with the type of scrap being handled. Some smelters do considerable preparation to upgrade and segregate scrap. Those with more limited facilities bypass some of the preparation steps and rely upon the furnace to burn up combustible contaminants. Here, contaminating metallics taken up into the melt can be diluted with relatively pure scrap, while some free iron can be raked from the furnace bottom.

New clippings and forgings are largely uncontaminated and require little presmelter treatment other than sorting, either manual or mechanically to remove obvious nonaluminum material. This scrap is stored in tote boxes and charged directly into the furnace forewell.

Borings and turnings are often heavily contaminated with cutting oils. In spite of this fact, some plants charge this material directly into the forewell. Most, however, pretreat this material. Typically, this material is received in long, intertwined pieces and must be crushed in hammermills or ring crushers. The crushed material is then fed into gas-or-oil-fired rotary dryers to remove cutting oils, grease, and moisture. After drying, the material is screened for removal of fines, with the oversize passing through a magnetic separator to remove tramp iron. The undersize material would contribute excessive oxides if charged into the furnace. It is often sold as pyrotechnics.

Residues (drosses, slags, skimmings, etc.) present a formidable processing problem. In addition to 10 to 45 percent metallic aluminum, the residues contain oxides, carbides, fluxing salts, and other contaminants. To recover the metallic aluminum it is necessary to liberate it from attachment to the contaminants. This can be done in either wet or dry processes.

Most common is the process in which the material is crushed,in hammermills, screened to remove the fines, and passed through a magnetic separator to remove free iron. Large amounts of dust are created in this circuit and provide a source of air pollution. Normally the dust emissions are controlled by baghouses. Wet dust collection is done occasionally.

The dry residue, after aluminum removal, is piled on the plant site in the open. Markets for the high alumina material exist and are being developed but only for materials very low in soluble salt content.

Other plants process residues using wet techniques. Generally, the raw material is crushed and fed into a long rotating drum. Water is passed through the drum to wash the feed, carry away the fluxing salts and chemicals, and liberate the aluminum. The washed material is then screened, dried, and passed through a magnetic separator. The nonmagnetics are then ready for the smelter. Fine particulates, dissolved salts, and screening undersize are all sources of water pollution.

Because of additional equipment needed, the technical knowledge required, and specialized processing problems involved, the large scale processing of residues is limited to larger smelters or specialty operations. Large smelters continually purchase residue products from small smelters not equipped to process their own. Residue products are always purchased on the basis of analysis and metal recovery.

In some plants sheet and castings may be charged directly into the reverberatory forewell, as received. In most cases, these types of scrap go to crushers which reduce them to small dimensions. The crushed material is passed along vibrating screens to remove pulverized nonmetallics and magnetic separators to remove free iron.

Aluminum scrap containing considerable amounts of iron is generally pretreated to eliminate the iron. This may be done by crushing followed by magnetic separation or, as is more commonly the case, the iron is removed in a sweating furnace. The operation of the sweating furnace has been previously described. Fumes from the furnace are generally passed through an afterburner before being emitted to the atmosphere.

In summary of the various presmelter treatments employed, only the wet processing of drosses and slags appears to provide a source of water pollutants.

3. Smelting

Since the function of the secondary smelter is to remelt the scrap material, remove the impurities, and produce a marketable specification product, it is well to understand a fundamental chemical constraint. In displacement reactions, only those elements that occupy positions above aluminum in the electromotive series can be removed from the molten mixture. Of the elements above aluminum in the series, only magnesium is present in the scrap to any appreciable extent. Calcium and sodium might be present in trace amounts, but their concentrations would be well below specification limits and are generally removed if magnesium is removed. Also lead can be removed with small additions of sodium.

The only method for producing secondary aluminum alloys is to enrich the less pure aluminum scrap with high-purity aluminum scrap or primary aluminum. Only by diluting the contaminants can the molten metal be brought to the desired specifications. Thus, manufacturing secondary aluminum alloys is a blending process in which each element is brought into specification by dilution and addition. This practice is in direct contrast to primary alloy production where the specified elements are added to pure aluminum to satisfy the alloy requirements. Dilution chemistry, then, is the science practiced by the secondary smelters.

The reverberatory furnace is the workhorse of the smelting industry. It is a rectangular furnace usually ranging in capacity from 30,000 to 180,000 lbs. The furnace is direct fired to the molten bath and the scrap is melted by the molten aluminum "heel", already present in the furnace. The furnace fuel may be either natural gas or fuel oil and from 2,000 to 4,000 Btu of input (depending upon scrap) is required to melt a pound of aluminum alloy and bring it to a casting temperature. Approximately 10 percent of the heat requirement is the latent heat of fusion.

Although the reverberatory furnace is equipped with side doors for charging heel material and cleaning, it is also equipped with a trough-like feeder on the front called a "forewell". Because molten metal rises to the same height in the forewell as in the furnace, charging scrap into the forewell is made convenient. Rotary furnaces are also being used by some companies and are successful in processing low-metallic raw materials. The principal disadvantages of a rotary furnace are low capacity and unsuitability for alloying and producing a homogeneous product. The principal advantages of a rotary furnace over a reverberatory furnace are the hot fluxing of oxides and a mechanical mixing action.

Generally, the smelting of aluminum scrap with reverberatory furnaces consists more or less of seven operations or tasks. These are charging scrap into the furnace, addition of fluxing agents, addition of alloying agents, mixing, removal of magnesium (demagging), skimming and degassing. Any given smelter may not necessarily incorporate all seven steps, as demagging or addition of alloying agents in the case of deoxidant producers, and may not follow the above order. There is some variability in the secondary aluminum industry as to precise techniques used in each step.

Charging. The furnace or heat cycle begins with charging aluminum scrap into the furnace, although this can vary depending upon whether the furnace has been completely emptied from the previous heat. Many times furnace operators leave from 9 to 16 inches of molten metal in the furnace with which to start the next cycle. This is possible by tapping the furnace to a measured level above the base. The molten metal remaining is called a "heel" and it saves about 4 hours in the ordinary furnace cycle. If a heel is not maintained in the furnace from heat to heat, the cycle begins by charging heavy-aluminum heel material into the furnace. Although the amount of heel material charged to the furnace depends upon furnace size, it is usually 20 percent of furnace capacity. This metal must be completely melted, sampled, and skimmed before charging the furnace can begin. While operating with a molten heel does considerably shorten the furnace cycle, it also leaves behind in the furnace finished metal that has incurred all costs except casting. The use of a heel often depends upon the above factors as well as the availability of good heel material, price and the composition of the next furnace heat. Large smelters usually operate with a heel in the furnace, since they are often producing the same specification ingot in continuing heats. This practice permits many economies because suitable heel material commands a premium price when purchased.

A forklift truck or front-end loader is used to charge the furnace with material selected from the five classes of scrap discussed earlier. Sheet and cast material are usually added first. After this material has been charged into the furnace, the slag is skimmed and the metal is sampled to determine the composition of the melt. If necessary, silicon is added, but caution is exercised to avoid exceeding the silicon solubility limit. After the silicon content has been adjusted, copper is adjusted to specification. Copper is often introduced in the form of high-copper borings and turnings or radiators that contain from 40 to 45 percent copper with the balance aluminum.

It can take anywhere from 18 to 36 hours to charge a furnace to capacity depending on the size of the furnace and the scrap being charged. Each charge must be followed by a control analysis to enable the furnace operator to select the raw material for the next charge. Because the furnace operator must know what he is adding to the furnace, it is vitally important that raw materials be tagged with accurate analysis.

Although heavy scrap is fed into the furnace during the earlier charging cycle, borings and turnings are frequently used after copper and silicon adjustments have been made. As the furnace nears capacity, it is charged with scrap whose analysis closely approximates that of the desired final product. Final silicon and copper adjustments complete the charging cycle. A melt may require a check of from 12 to 15 control samples to reach specification metal.

Upon reaching specifications, either the magnesium must be removed or the metal must be degassed before pouring, but not both. If the melt is demagged, as a result, degassing is achieved at the same time. If it does not need demagging, then the general practice is to degass it before pouring. Any hardeners required by specifications are added at this time. This final purification requires approximately 3-4 hours.

Fluxing. Because molten aluminum in the forewell oxidizes rapidly when exposed to air, it must always be covered with a molten flux to retard oxidation. Therefore, scrap material that is charged into the forewell of the furnace is "puddled" quickly into the molten metal where it is shielded from oxidation by a layer of molten flux.

Flux may be either a commercial grade or a specific salt mixture that is desired by each individual smelter. The flux most commonly used is a mixture of 47.5 percent NaCl, 47.5 percent KCl, and the remaining 5 percent a fluoride bearing salt such as cryolite. Some smelters have reduced the cryolite concentration to 3 percent or less of the flux. To minimize their operating costs, many smelter operators mix their own fluxes. The amount of flux used may vary but is approximately 1 lb. of flux for each pound of nonmetallics charged to the furnace.

Although the primary use of a flux is to lessen oxidation and gas absorption, it also exerts a purifying action on the aluminum by cleaning the metal and removing dissolved gases. All solid fluxes are hygroscopic and must be kept dry. Any moisture introduced into the molten metal causes hydrogen gas to be absorbed into the metal from the decomposition of the water.

Despite the use of flux, oxidation and metal losses are still high for finely divided scrap such as borings and turnings. Oxidation rates increase with exposed surface area and finely divided scrap particles cannot be economically melted because metal losses are too high. In addition to high metal losses, the oxides formed are detrimental to the molten metal since they are of approximately the same density as the molten aluminum alloys and, if not removed, are entrapped in the metal.

Aluminum oxide collecting on the sides of the furnace is exposed to continuous high temperature and is converted into an extremely hard oxide. This oxide, as well as other nonmetallic inclusions, will nick or even break carbide and diamond tools and must be eliminated by fluxing. Fluxes clean the molten metal by reacting with these unwanted contaminants as they are brought to the surface. Once the oxide inclusions are entrapped in the flux, they can be removed from the molten bath by skimming. The oxides could be skimmed without fluxing but metal losses would be extremely high.

Alloying. Alloying agents normally added to the aluminum melt include copper, silicon, magnesium, and zinc. Usually these are added after the furnace has been charged with aluminum scrap and analyzed for its composition. The amounts of additions required to bring it up to specifications are then added usually as scrap high in the concentration of the desired element or as in the case of silicon, added in the pure state. These are added to the forewell and stirred into the melt with an inert gas (N_2), or with mechanical and hydraulic puddlers although silicon is generally added inside the furnace. The addition of the alloying agents and the stirring produces no solid waste and only minor amounts of fumes and dust that are removed from the working area by the hoods over the forewell.

Mixing. Mixing of the metal to insure uniform composition and to agitate the solvent fluxes into the melt is generally accomplished by injecting nitrogen gas or by use of mechanical puddlers. Aside from homogenizing the melt, the mixing step is beneficial in bringing to the surface dissolved gases, such as hydrogen, and intermixed solids. Once on the surface, the impurities combine with the fluxing agent and can be skimmed off.

Mixing is performed nearly continuously in the reverberatory furnace. Mixing often does a double duty and serves as a degassing operation. The mixing operation employs no water and produces no solid wastes. Only when the mixture of nitrogen and chlorine is used is there a source of air pollution.

Magnesium Removal (demagging). Scrap aluminum received by the secondary smelters averages about 0.3 to 0.5 percent magnesium, while the product line of alloys produced averages about 0.1 percent. Therefore, after the furnace is fully charged and the melt brought up to the desired chemical specification, it is usually necessary to remove the excess magnesium. This is done with chlorine or chlorinating agents such as anhydrous aluminum chloride or chlorinated organics, or with aluminum fluoride. Magnesium chloride or magnesium fluoride is formed and collected on top of the molten melt. As the magnesium level is depleted, chlorine will consume aluminum and the aluminum chloride or aluminum fluoride present in excess volatilizes into the surrounding air and is a source of air pollution.

Magnesium is the only metal removable from the alloy in this manner. Other metal alloy levels must be adjusted by the addition of either more aluminum dilution or more of the metal.

Chlorination, the method preferred by the industry for demagging is performed at temperatures between 1475 and 1550°F. As a rule of thumb, the reaction requires 3.5 - 4.0 lbs. per pound of magnesium removed. Chlorine gas is fed under pressure through tubes or lances to the bottom of the melt. As it bubbles through the melt it reacts with magnesium and aluminum to form chlorides which float to the melt surface where they combine with the fluxing agents and are skimmed off. Because magnesium is above aluminum in the electromotive series, aluminum chloride will be reduced by any available magnesium in the melt. At the beginning of the demagging cycle, the principal reaction product is magnesium chloride. As magnesium is removed and there is less available for reaction with chlorine, the reaction of chlorine with aluminum becomes more signficant, the reduction of the aluminum chloride by magnesium becomes less likely, and the production of aluminum chloride, a volatile compound becomes significant. The aluminum chloride escapes and considerable fuming results from the chlorination, making ventilation and air pollution equipment necessary. Control of fumes is done by wet scrubbing and thus is a source of water contamination.

Aluminum fluoride, as a demagging agent, reacts with the magnesium to form magnesium fluoride which in turn combines with the flux on top of the melt. Here it is skimmed off. In practice, about 3.5 to 4.3 lbs. of aluminum fluoride are required per pound of magnesium removed. The air contaminants exist as gaseous fluorides or as fluoride dusts and are a source of air pollution. The fluorides are controlled by either dry or wet methods. When done dry, a solid waste problem exists. When done wet both a water pollution and solid waste pollution problem exist.

Some operators in the secondary industry are little concerned with the magnesium content of their product, as the deoxidant manufacturers, and they make no attempt at removing it. They thus do not contend with the magnitude of fumes that the demaggers do and as a result do not require an extensive air pollution control equipment and related water usage.

Skimming. The contaminated semisolid fluxing agent known as slag (sometimes as dross) is removed from the surface of the melt in the forewell with a perforated ladle or similar device that permits molten metal to drain back into the forewell. This is done as needed and also before tapping the reverberatory furnace to pour. The slag is placed in pans to cool or in a water-cooled "dross cooler".

Once cooled, the slag is either stored until shipped to a residue processor, reprocessed by the company, or is dumped. If stored in the open, it is a source of ground and runoff water contamination because of contained soluble salts (NaCl, KCl, $MgCl_2$). During slag cooling, thermiting generates fumes and is a source of air pollution if the slag is not properly conditioned and cooled. The thermiting, as well as reactions in the smelting, produce nitrides and carbides of aluminum, which can react with water or water vapor in the air to release hydrocarbons and ammonia to the atmosphere. The ammonia also may become a component of water pollution.

Degassing. Molten aluminum will readily absorb hydrogen gas from the atmosphere or other sources of moisture or water vapor. Since gases dissolved in the metal will separate out during solidification, the customer demands that the metal be gas free. If not, the entrapped gas present in the metal would expand during fabrication and form blisters or possibly interdendritic imperfections at the grain boundaries. Cast products thus formed would have unusually high porosity from the absorbed gases.

Because aluminum will hold hydrogen gas in solution in direct proportion to the temperature of the molten metal, it is degassed at the lowest possible temperature. It would do little good to degas the metal and then raise the temperature of the molten metal to a higher level where it could absorb more gas. Consequently, degasification is the last operation before the molten metal is poured, if demagging is not carried out. The temperature rise caused by exothermic reaction of the chlorination process would destroy the effectiveness of degasification if it were done in reversed sequence.

The metal is degasified by bubbling dry nitrogen, chlorine, or a mixture of the two gases through the molten metal bath. Chlorine gas is far more effective since it degasses the metal chemically by forming hydrogen chloride while nitrogen sweeps the gas out of the molten metal mechanically. With few exceptions, any smelter equipped to use chlorine does use chlorine.

Safety hazards involved in using and storing chlorine impose many limitations upon its use. Fire departments in many large cities have strict codes regarding how much chlorine can be stored around occupied buildings. A small working supply of the chlorine is stored outside the smelter in steel cylinders under heavy pressure and is piped into the furnace as a liquid. The chlorine usually does not become a gas until it enters the furnace. A carbon "lance" projecting into the molten aluminum is used to introduce the elemental chlorine, and the gas bubbling up through the metal bath cleans and degasses the metal.

The chlorine combines with hydrogen and aluminum in the furnace according to the following equations:

$$2\,Al + 3\,Cl_2 \rightarrow 2\,AlCl_3 \qquad (1)$$

$$H_2 + Cl_2 \rightarrow 2\,HCl \qquad (2)$$

Unless smelters are equipped with adequate air pollution control systems, they are hampered by the severe fuming caused by the chlorine during degassing. Because of this fuming and other hazards involved, few smelters use elemental chlorine for degasification if they do not have adequate ventilation and air pollution control equipment. Smelters without this equipment commonly use nitrogen or some other inert gas.

4. Tapping the Furnace

Twenty-four to 42 hours after the furnace cycle is started, the metal is ready for pouring. Charging the furnace, reaching specification composition by blending, chlorinating the magnesium, and degassing the metal are all time consuming. Even though furnaces are operated on a continuous basis, each heat is a batch operation and is only a part of a continuing series.

The melt is cooled to approximately 1,350°F for pouring. Low pouring temperature, short metal launders, and preheated molds are all helpful in minimizing hydrogen pickup from the atmosphere. The exact pouring temperature and method of pouring, however, depend largely upon the alloy and the product line of the individual smelter.

5. Product Line

The product-lines of the secondary aluminum smelters have been grouped into five categories. These are specification alloy ingots, billets, hot metal, notched bar, and shot.

Specification Alloy Ingots. The most important product of the secondary aluminum industry is specification alloy ingot to be used by foundries for casting. Most smelters concentrate on a few of the basic alloys. Normally, automatic casting methods are used to fill the ingot molds. The molds are generally the 15 or 30-pound size.

Cooling is often accomplished with a water spray that contacts both the molds and hot metal as they move along a conveyor track above a casting pit. Cooling is also performed by a few companies by passing water through passages in the mold, in which case water does not contact the hot aluminum metal. In some cases, the molds are cooled by passing the hot ingots through a cooling tunnel blown with a water mist-air mixture, thus generating no wastewater.

The water used for cooling may be recirculated or sent to a cooling tower and recirculated, or it may be used only once and discharged. Recirculated water often builds up sludge in both the cooling tower and cooling pit. This necessitates sludge removal at regular intervals and is accompanied by a discharge of system water.

Billets. Secondary aluminum for use in the extrusion industry is cast into 1000-pound billet logs. The long cylindrical billets are 6 to 10 inches in diameter and about 10 feet long. The molds are arranged in circular arrays. A riffle above each array splits the molten metal into fractions so that all molds are filled simultaneously. Water lines inside the molds cool the billets. Billets are water quenched on leaving the mold. Each billet log is then removed and cut into shorter 2-foot sections. These "billets" are then placed in a homogenizing furnace where they are given a high-temperature soaking treatment to eliminate or reduce segregation by diffusion. This preheating treatment provides the desired metallurgical structure and upon removal from the homogenizing furnace, the billets are ready for shipment to extruders who will form the billets into fabricated products such as storm doors, window frames, etc.

Hot Metal. In some cases "hot metal" is tapped from the reverberatory furnace into preheated portable crucibles. The crucibles are sealed, placed on a flat bed truck and transported directly to the customers for use. Presently, crucibles with capacities of 15,000 lbs. and 38,000 lbs. are used.

Notched Bar. Notched bar is used as a deoxidant by the iron and steel industry and is normally cast in various 5 lb. shapes. Seven grades are produced, each grade having a different aluminum content. Notched bar molds are cooled either with water sprays, internal water lines, or with air. The water used may or may not be cooled and recirculated.

Shot. Shot is also used as a deoxidant and as an alloying element and comes in various compositional grades. Shot is produced by pouring the molten metal onto a vibrating feeder where perforated openings in the bottom allow the molten metal to drop through into a water bath below. The droplets solidify in the water, are dried, sized and packed for shipment. The oversize shot is recharged into the furnaces. Quenching water is sometimes sent to a cooling tower and recirculated. Sludge build-up occurs and must be removed regularly on an annual or semi-annual basis. Also, a low water temperature (about 65°F) is critical for the production of good quality shot.

C. RECENT TECHNOLOGICAL CHANGES*

The rapid growth of the secondary aluminum industry is best evidenced by the fact that secondary aluminum production increased by 110 percent between 1960 and 1966. During the same period primary aluminum production increased by less than 50%. This rapid rate of growth would indicate that the 60's were the real "takeoff" period for the secondary aluminum industry. Although the secondary aluminum industry dates back to the turn of the century, World War II acted as the catalyst for industry expansion. Before World War II there were only 25 smelters in the United States, many of which were little more than remelters. Production of secondary aluminum was 80,362 short tons in 1940 compared with 693,031 short tons in 1966--an almost ninefold increase.

1. Scrap Processing

Only in the last few years has the scrap processing industry reached its present state of sophistication. Until fairly recently, aluminum scrap (discounting casting alloys) came in only three broad classes: 2S, 3S, and 24S. As the metalworking industry became more mature, however, a new alloy came to be developed for each specific job. It was primarily the technology within the metalworking industry that prompted the scrap dealer to become more knowledgeable about the metals he handled. The decision by scrap dealers to sort scrap by identifiable means and sell according to classification was purely economic. When a mixed load of aluminum scrap will command only the price of the poorest aluminum scrap portion, many potential profits are sacrificed. Economic rewards are maximized when the different classes of scrap are segregated into shipments of salable scrap.

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*Much of this chapter is adapted from "Impact of Technology on the Commercial Secondary Aluminum Industry," Donald L. Siebert, U.S. Bureau of Mines IC 8445, 1970.

Dealers have become aware of the harmful effects that contaminants such as zinc or stainless steel have on aluminum smelting and have made an extra effort to remove them from scrap shipments. Venetian blinds, painted materials, screen, and neoprene-coated materials are also difficult for a smelter operator to process and may cause emission of polychlorinated biphenyl compounds and other complex organics. Aluminum foil, although a high-grade aluminum product (2S), creates a problem for the smelter because metal losses from oxidation are extremely high. Paper-back foil is impractical for processing in the reverberatory furnace since it burns readily. Any raw material containing carbonaceous or flammable material is undesirable for smelting since the aluminum oxidizes and the combustibles burn to ash. It might be possible to reclaim this material by first charring the material in a controlled atmosphere and gradually increasing the temperature until the aluminum coalesced into tiny nodules. The coalesced aluminum could then be separated from the carbonaceous material by screening or washing.

2. Smelting

There has been no appreciable change in smelter metallurgy for over 20 years. While it is true that hundreds of compositions of wrought and casting alloys have been developed during this period, the metallurgy has remained basically unchanged. Like the scrap dealer, the smelter has also developed remarkable technological improvements in materials handling and preparing scrap for the furnace. These improvements would not have come about had the smelting industry not been ripe for change. In the early 50's many smelters continued to move both raw materials and finished products by hand labor. Family-owned smelters often maintained such a cloak of secrecy around their organizations that even equipment companies were not permitted within the plant for fear that processing secrets would be discovered and passed on to competitors. Smelters either built their own equipment or purchased equipment and installed it with their own manpower. There was little exchange of information, and plant visits between smelter operators were unheard of. Indirectly, a competitor determined product price since each smelter operator would match a competitor's price regardless of unit production costs. The net effect was that although the industry grew, technology stagnated and profits were erratic.

Paradoxically, it was the rapid growth of the secondary industry that forced smelter operators out of these parochial practices. Many organizations brought in engineers and professional managers for the first time. Professional managers regarded the smelter as a manufacturing company instead of a family business. Unaffected by close family ties, the professional cadre focused their efforts upon the perpetuation of the company. Cost accounting was introduced to determine the unit cost of each operation. This enabled management to focus on high cost operations and to introduce appropriate cost cutting procedures. Labor was found to be an extremely expensive reagent, and wherever possible, mechanization and even automation were introduced. Long-range planning became commonplace and the company discontinued operating under a short-term family objective to produce an "acceptable" profit. Professionalism took over and modernized the organization by making commonplace technical knowledge, marketing strategy, and managerial competency.

Most of the technology to emerge from secondary aluminum smelting had its birth after the smelter assumed the professional posture just described. The need for technological innovation is especially important to the secondary smelters because the raw materials with which they must work are constantly changing. Painted siding, beverage containers, and other consumer products that are being manufactured for today's household have already entered the raw materials inventory. Since secondary industries have no choice of the raw materials they must handle, they must learn to process whatever becomes available.

In addition to the broad categories of improved material handling methods, increased manpower utilization (higher productivity), and more sophisticated approaches to quality control, the secondary smelters have had to develop a number of specific practices. A summary of the most important of these technological innovations to emerge from the secondary smelter is as follows:

1. Improvements in the processing of raw materials
2. The tremendous increase in furnace capacity
3. The salvaging of drosses and skimmings
4. Shipment of hot metal
5. Quality control
6. Air pollution control
7. Nitrogen "agitation," mechanical and hydraulic "puddlers," and molten metal recycle pump

D. INDUSTRY SEGMENTS

Segmentation of the secondary aluminum industry presents an extremely difficult task for a number of reasons. Oftentimes it is questionable as to which segmentation scheme best fits the particular industry. Also, plants in each segment may be alike in terms of the segmentation scheme used but may differ from each other in other respects.

In addition, it may be difficult to obtain enough information on a particular plant to determine in which segment it would best fit. Each approach therefore has its own limitations and the best solution is to find a scheme which best characterizes the industry. Ideally, the best analysis would be on a plant-by-plant basis, but unfortunately, this may not be possible due to such limitations as time and budget available.

1. Segmentation of the Industry

It seems best to segment the industry into groups of plants which may have similar processing problems. The most effective way of accomplishing this is to classify each plant as to the major raw material input and the final product produced since these two factors combined determine the process or processes to be used. In turn, the process used determines the ultimate water use.

Once the industry has been segmented in this manner, each segment can then be subdivided into large and small plants. This further division will be helpful in determining capital availability in each segment. We have arbitrarily chosen the break point between small and large smelters at the level of 50,000 lbs. per day of finished product production. This is equivalent to approximately 1 million lbs./month.

Following the argument presented, we have classified the U.S. secondary aluminum smelters into six segments in terms of size (amount of product produced), type of product, and major raw material input. These segments are:

1. large, ingot producers using drosses as a major portion of their raw material input
2. small, ingot producers using drosses as a major portion of their raw material input
3. large, ingot producers using scrap aluminum
4. small, ingot producers using scrap aluminum
5. large, billet, plate and sheet manufacturers using scrap for their major raw material input
6. small, billet, plate and sheet producers using scrap for their major raw material input

Previous information gathered by Battelle for the EPA indicates that there are approximately 85 secondary smelters in the billet and ingot manufacturing industries. In addition to these listed there are operations which are integrated within manufacturing activities such as the sheet makers and extruders who produce an end product, bringing the total to more than 100. Of these 100 or more plants, we have reasonably complete information on 69 of the largest (Table III-2) which represent in excess of 94 percent of the total production and 90 percent of the total employment in the U.S. secondary aluminum smelting industry. These 69 plants will therefore be the subject of this impact study and will be analyzed for possible impact according to the above proposed segmentation.

2. Types of Firms

A vast majority of the firms have one plant operation and are either family-owned or owned by small corporations. A minority in number, but which represent a large portion of the production, are either large corporations or subsidiaries of large corporations. On a company basis, the two largest companies presently supply 30 percent of the secondary aluminum produced. The next four largest companies supply another 30 percent, or 60 percent of product is by the six largest companies.

Data is also available from the Bureau of the Census dealing with the value of shipments in 1963 and 1967 and is presented in Table III-3. The production and value of shipments information combined provide an indication of how much the secondary aluminum smelting industry is dominated by large companies.

The size of a firm may range from six employees, in the case of a small family-owned company with only one plant, up to five or six thousand employees, in the case of a conglomerate with several plants with only a portion of the employment due to secondary aluminum smelting.

The level of integration in these firms is low, with the exception of some of the billet manufacturers who do produce siding, doors, windows, and other marketable products. Most smelters buy aluminum scrap from scrap collectors refine the aluminum scrap to produce metallic aluminum alloys, and then sell these alloys, mainly in the form of ingots, hot metal and billets, to users who shape the alloy into a finished produce. On the whole, the particular function of a secondary aluminum smelter is to transform a relatively low-value aluminum scrap, which would otherwise be wasted into a specification alloy which can be further processed into a useful product. The general product of this industry is in the form of either 15 or 30 lb. ingots or 500,600,800 and 1,000 lb. sows. These are generally in specification alloys and are mainly used for die casting and to a lesser extent for permanent mold and sand casting. Many smelters manufacture a wide variety of these alloys. Some of the smelters also produce a semi-specification material for use in steel mills as de-oxiders. The de-oxidizers may be in the form of small ingot, notched bar, shot, and certain other special shapes.

TABLE III-2

SECONDARY ALUMINUM SMELTERS

COMPANY	LOCATION
Aetna	Los Angeles, California
Allied Metal	Chicago, Illinois
Alsco	Akron, Ohio
Alside	Akron, Ohio
Aluminum & Magnesium, Inc.	Hot Springs, Arkansas
Aluminum & Magnesium, Inc.	Corona, California
Aluminum & Magnesium, Inc.	Oak Creek, Wisconsin
Aluminum & Magnesium, Inc.	Sandusky, Ohio
Aluminum Smelting & Refining Co., Inc.	Maple Heights, Ohio
Apex Smelting Co., Division of Amax Aluminum Co.	Chicago, Illinois
Apex Smelting Co.	Cleveland, Ohio
Apex Smelting Co.	Long Beach, California
Atlantic Metals Corp.	Philadelphia, Pennsylvania
Aurora Refining Co.	Aurora, Illinois
Barmet Industries	Akron, Ohio
Barmet Industries	Uhrichville, Ohio
Charles Batchelder Co.	Botsford, Connecticut
Batchelder-Blasius, Inc.	Spartenburg, South Carolina
Bay Billets, Inc.	Sandusky, Ohio
Joseph Behr	Rockford, Illinois
Berman Bros. Iron & Metal Co., Inc.	N. Birmingham, Alabama
Bohn Aluminum	Southfield, Michigan
Bradley Metals	Cleveland, Ohio
W.J. Bullock, Inc.	Fairfield, Alabama
Donald Carroll	Bensenville, Illinois
Cleveland Electro Metals	Cleveland, Ohio
Crown Aluminum	Roxboro, North Carolina
Diversified Metals Corp.	Livia, Kentucky
J.R. Elkings, Inc.	Brooklyn, New York
Excel Smelting Corp.	Memphis, Tennessee
Fruehauf Corp.	Decatur, Alabama
Garfield	Cleveland, Ohio
Globe	Oakland, California
Gulf Reduction Corp.	Houston, Texas

TABLE III-2 (Cont'd.)

COMPANY	LOCATION
Hall Aluminum Co.	Chicago Heights, Illinois
Harco Aluminum Co.	Chicago, Illinois
Hillyard	Spokane, Washington
Hy-Duty Alloy	Seattle, Washington
Intercontinental Alloy	Joliet, Illinois
W.F. Jobbins (Subsidiary of U.S. Reduction)	Aurora, Illinois
Kimerling & Sons	Birmingham, Alabama
R. Lavin & Sons, Inc.	Chicago, Illinois
Lissner	Chicago, Illinois
Lupton	Philadelphia & L.A.
Materials Reclamation Co., Inc.	Seattle, Washington
McGowan Metal	Ontario, California
Michigan Standard Alloys	Benton Harbor, Michigan
Newark Processors	Newark, Ohio
North American Smelting Company	Wilmington, Delaware
Ohio Valley Aluminum Co.	Shelbyville, Kentucky
Pioneer Metals, Inc.	Los Angeles, California
Robert Russell, Metals Division	Miami, Florida
Rochester Smelting & Refining Co., Inc.	Rochester, New York
Roth Smelting Company	Syracuse, New York
The George Sall Metals Co., Inc.	Philadelphia, Pennsylvania
Seattle Iron and Metal	Seattle, Washington
S-G Metals Industries, Inc.	Kansas City, Kansas
Southwire Co.	Carrollton, Georgia
S & S Supply	Fontana, California
Tomke Aluminum	Baltimore, Maryland
United States Aluminum Corp. of Pennsylvania	Marietta, Pennsylvania
U.S. Reduction Co.	East Chicago, Illinois
U.S. Reduction Co.	Russellville, Alabama
U.S. Reduction Co.	Toledo, Ohio
U.S. Reduction Co.	Ontario, California
U.S. Reduction, Federal Metals Division	Alton, Illinois
Vista Metals	Ontario, California
Wabash Smelting, Inc.	Wabash, Indiana
Wabash Smelting, Inc.	Cleveland, Ohio

TABLE III-3

PERCENT OF VALUE OF SHIPMENTS OF INGOTS AND BILLETS ACCOUNTED FOR BY THE LARGEST COMPANIES 1963 AND 1967

Product	Year	Total (million) Dollars	4 Largest Companies	8 Largest Companies	20 Largest Companies	50 Largest Companies
Ingot	1963	238.9	44	62	85	99
	1967	302.9	44	64	88	99+
Billet	1963	13.9	85	99	100	100
	1967	39.3	72	97	100	100

SOURCE: U.S. Bureau of the Census, 1967.

Further, a small segment of this industry consumes aluminum for the manufacture of extrusion billets. In this case the input is almost exclusively billet grade scrap which is remelted and then cast into the billets. Some, if not most, of the billet manufacturers also manufacture semi-finished and finished products such as extrusions and building construction items such as doors, windows, storm doors, etc.

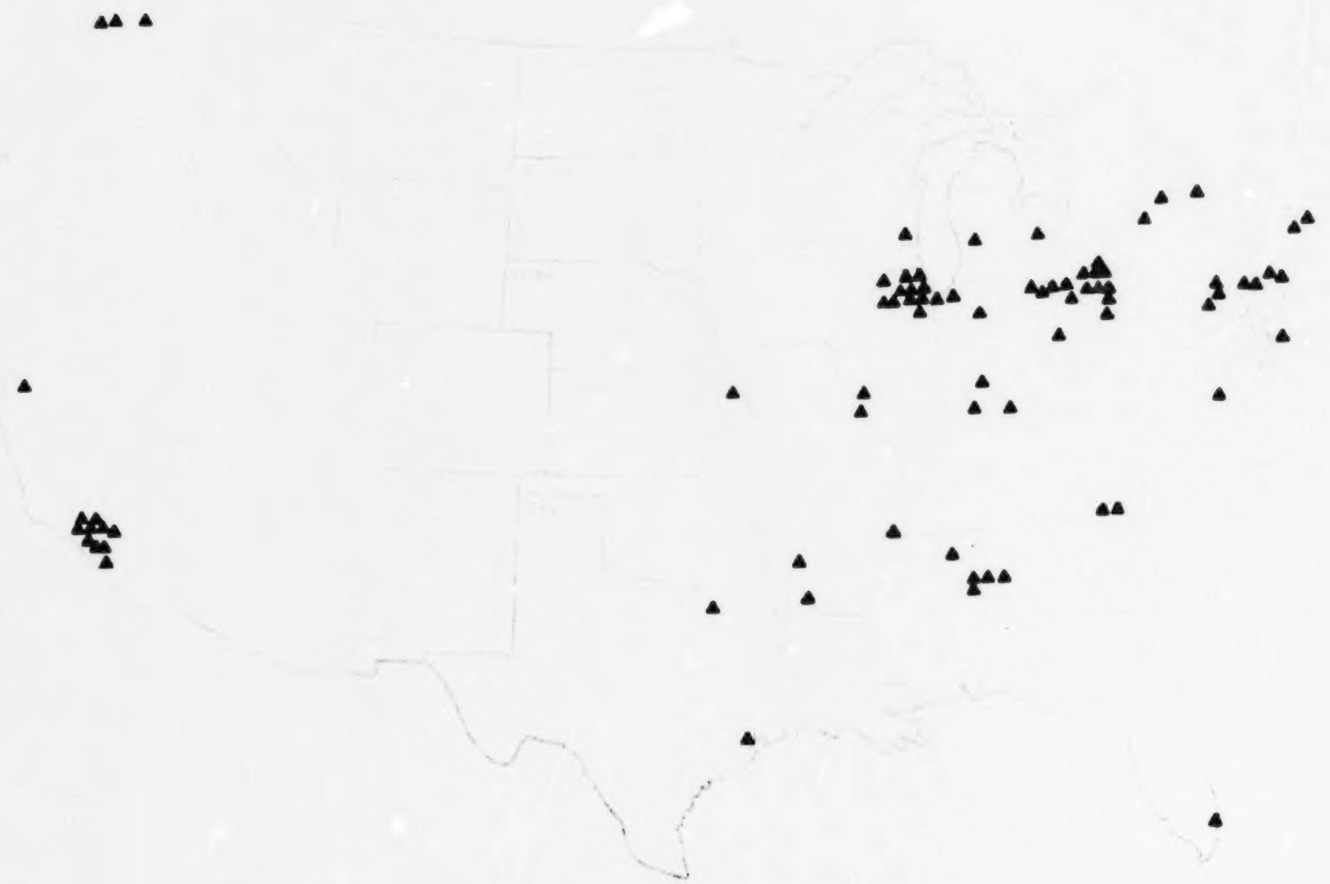
With the exception of those which are owned by conglomerates, the level of diversification of most of these companies is low. There are a few singular exceptions where the facility not only produces secondary aluminum but handles brass, precious metals and other completely unrelated materials such as building products, carries out steel warehousing and other miscellaneous activities.

3. Types of Plants

Plants in this industry vary all the way from very small operations located on sites as small as one acre and employing as few as six people to fairly complex ones with on the order of 400 employees at a given site, occupying up to 50 acres. At the same time, production of aluminum alloy can range from 500,000 pounds per month up to 9 million pounds per month from a single plant. The production at each plant can vary significantly. Unlike primary aluminum plants, secondary smelters do not operate around the clock for seven days. They may operate continuously five days a week and thus can step up production by operating operating extra shifts. There is not necessarily a relationship between either employment and site area or production and site area of a plant. This is noted from the fact that several very large producers in metropolitan areas have small plant sites due to the high cost of land.

Plants in this industry vary in age with some of the facilities 40 to 50 years old with additions having been made over the years and in some cases being currently made. Due to the unsophisticated nature of this industry, there is little need for extensive reliance on the buildings themselves to do anything more than shield from the weather, thus any safe structure can be utilized.

Most of the plants currently producing secondary aluminum metal are located near heavily industrialized areas which give them proximity to a supply of scrap as well as to their customers (see Figure III-1). There is no need for them to be near plentiful supplies of electrical power and water as in the case of primary aluminum smelters. Most of these plants are located in the Midwest, in or near the Chicago and Cleveland metropolitan areas and in the West, in the Los Angeles area. The Chicago metropolitan area alone produces almost 28 million pounds per month from 10 plants which represents about 18% of the total production from the 69 plants represented in this report. In addition, within



Sources: 1. Siebert, Donald L., Impact of Technology on the Commercial Secondary Aluminum Industry, U.S. Bureau of Mines, IC 8445, 1970.
2. Arthur D. Little, Inc., information

FIGURE III–1 GEOGRAPHIC DISTRIBUTION OF SECONDARY ALUMINUM SMELTERS IN THE UNITED STATES

a 100-mile radius of downtown Chicago, approximately 45% of the U.S. secondary aluminum production can be accounted for. Within a similar radius of Cleveland, another 20% can be found. The East Coast has plants located near the New York City-Philadelphia area. There are none in the Rocky Mountain states.

Most facilities are generally operating at relatively low technological levels. Techniques for smelting have not changed basically in the last 40 years, although furnaces today are much larger and are equipped with much greater heat input capability, thus are able to generate more output per man-hour. Techniques for preparation of scrap by means of crushers and sorting are reasonably general. Preparation of turnings by crushing and drying is carried out in most plants. Dross processing is carried out by and large by companies who specialize in the processing. Most of their competitors either sell their skimmings to the dross processors or dump them.

The general efficiency of these plants is low in terms of technology and energy utilization (fuel, electric, and human) as compared to other manufacturing industries. Heat recoveries from the furnaces are low and many operations which could be automated are still accomplished by manual labor. By and large the reason that it is possible for new companies to enter the business as readily as they can lies in the fact that the general level of operations are reasonably labor intensive and are not capital intensive. This further tends to indicate the lack of high level technology in the operation of this industry.

About the only exception that might be noted lies in the dry processing of drosses where sophistication has improved the processing to a level where enormous tonnages of material, if they are available, can be processed at relatively low costs, thus making this an attractive material.

Further, the level of mechanical auxiliaries and automated equipment is relatively low in this industry. As an example, very few plants have completely automated pouring and stacking equipment for handling their aluminum alloy ingots. A relatively small number of plants in the industry have mechanical puddling devices available to assist manpower in the puddling of scrap into the furnaces.

As with the firms, in general, the plants are not integrated to any great extent with the same exceptions as those which applied to the firms.

4. Percent of Industry Represented by Each Segment

Table III-4 presents a breakdown of production and numbers of plants and employees represented by each segment. Also presented are the percentages of total industry represented by each.

TABLE III-4

PLANTS, EMPLOYEES, AND PRODUCTION AND PERCENTS OF INDUSTRY TOTALS REPRESENTED BY EACH SEGMENT

	PLANTS		EMPLOYEES		PRODUCTION	
Segment[2]	Number	Percent of[1] Industry	Number	Percent of[1] Industry	Millions of Pounds/Month	Percent of[1] Industry
1	10	10	1200	22	38.4	23
2	6	6	140	3	4.4	3
3	24	24	2500	44	71.0	43
4	19	19	770	13	15.3	9
5	9	9	450	8	25.0	15
6	1	1	20	<1	0.7	0.5
Totals	69	69	5080	90	154.8	94

1. Percentages may not add due to independent rounding

2. Segments
   1. - large, ingot producers using drosses
   2. - small, ingot producers using drosses
   3. - large, ingot producers using scrap aluminum
   4. - small, ingot producers using scrap aluminum
   5. - large, billet, plate and sheet manufactueres using scrap aluminum
   6. - small, billet, plate and sheet producers using scrap aluminum

SOURCE: ADL Estimates

The large producers of ingot using scrap aluminum as a raw material, segment 3, represent by far the largest share of total industry in all three areas. Next, in number of employees and production, are the large producers of ingot using drosses as a raw material input, segment 1.

E. FINANCIAL PROFILES

In view of the fact that most of the plants are either privately held or are subsidiary operations of conglomerates, it is impossible to establish annual profits, cash flows or cost structures.

Only one company is publicly held where figures are available. Since this company does not represent average conditions within the industry, it would be inappropriate to use these figures to establish industry-wide trends.

We have utilized the most recent data on the secondary aluminum smelting industry, as developed in the 1967 Census of Manufacturers for an assessment of the financial profiles of the industry. Data for the 1972 Census is not expected to be available until late 1974.

The 1967 Census data provides the following financial information on the industry:

- Value of shipments (VS) represents the net selling values, f.o.b. plant, after discounts and allowances and excluding freight charges and excise taxes.
- Cost of materials includes:
  - a. the total delivered cost of all raw materials, semifinished goods, parts, components, containers, scrap, and supplies consumed or put into production,
  - b. the amount paid for electric energy purchased;
  - c. the amount paid for all fuels consumer for heat, power or the generation of electricity;
  - d. the cost of work done by others on materials or parts furnished by the reporting establishment (contract work); and
  - e. the cost of products bought and resold in the same condition.
- Capital expenditures include the cost of plant and equipment for replacement purposes, as well as for additions to productive capacity. Costs associated with plants under construction but

not in operation during the year are also included. Capital expenditures do not include plant and equipment furnished to the manufacturer without charge by governmental or private organizations. The value of rented facilities is also excluded.

- Payrolls - This total includes the gross earnings paid in the calendar year 1967 to all employees on the payroll of reported establishments. It follows the definition of payrolls used for calculating the Federal withholding tax. It includes all forms of compensation such as salaries, wages, commissions, dismissal pay, all bonuses, vacation and sick leave pay, and compensation in kind. It should be noted that this definition does not include employers' Social Security contributions or other non-payroll labor costs such as Employees' pension plans, group insurance premiums, and workmen's compensation.
- Value added by manufacture - This figure is derived by subtracting the total cost of materials (including materials, supplies, fuel, electric energy, cost of resales and contract work done by others) from the value of shipments including resales, and other receipts and adjusting the resulting amount by the net change in finished products and work-in-process inventories between the beginning and end of the year.

These data can be utilized to derive the following information shown in Table III-5.

- Value Added (VA) /Value of Shipments (VS)

  Since the value of shipments is a measure of tonnage produced by each segment, this is equivalent to value added per ton.

- VA - payroll (incl. suppl. expenses)/VS

  If local taxes, insurance and interest charges are subtracted from this column, we obtain an estimate of pretax cash flow per ton.

- Capital expenditures (CI)/VS

  This is an estimate of the average rate of capital investment per ton of production.

- Variable out-of-pocket costs (CV)/VS

  CV is equal to cost of materials plus payroll (including supplemental expenses such as welfare and social security contributions). When divided by value of shipments, this gives the out-of-pocket variable costs per ton.

TABLE III-5

MEASURES OF FINANCIAL PERFORMANCE OF SECONDARY ALUMINUM INDUSTRY SMELTING INDUSTRY[1]

BASED ON 1967 BUREAU OF CENSUS DATA

Payroll[2]	Materials[2]	VA[2]	VS[2]	CI[2]	VA[3] / VS	VA-Payroll[3] / VS	CI[3] / VS	CV[3] / VS
37.5	326.6	81.1	409.4	9.4	0.20	0.11	0.02	0.89

Note: VA = Value added by Manufacture
VS = Value of Shipments
CI = Capital Expenditure
CV = Variable out-of-pocket costs
See text for interpretation of the ratios derived

1. Includes numbers for both ingot and billet producers since the data do not reveal any significant differences between these categories.
2. Million dollars
3. Ratio of $/$

SOURCE: 1967 Census of Manufacturers

Interpretation of Ratios

VA/VS - A low ratio indicates that the difference between the value of the raw material used and that of the product produced is small.

CI/VS - A low ratio shows that there is not much capital investment or perhaps it consists of used equipment installed by in-house labor costs and that most capital expenditures are paid for via retained income without the use of long-term financing. It may also indicate a tendency to write off as current expenses what are really capital items.

CV/VS - A high ratio means low fixed charges, i.e. low book value of assets; depreciation is low; small long-term debt.

1. Profits

Net profit on sales for secondary aluminum smelters range from 1 to 2.5 percent. While some smelters list profits as low as 1 to 1.5 percent, most smelters consider a 2 percent profit on sales as standard.

2. Annual Cash Flow

Again annual cash flows are very difficult to determine since the company figures are not made public. Transactions in the secondary smelting industry are complicated and can change dramatically from month-to-month and even day-to-day.

Secondary smelters usually pay up to 75 percent of the purchase price of scrap in cash at the time of confirmation of shipment and the balance in 30 days. Consequently the cash prepayment for each railroad car of scrap will be approximately $5,000, and it may be days or even weeks before the scrap arrives at the smelter. In the meantime, smelter products are always sold on credit with payment required in 30, 60, or 90 days. Thus, a secondary smelter generally buys for cash and sells on loan credit. This financial arrangement generates a tremendous need for liquid capital and has been a powerful motivation in convincing the small family-owned smelter operators to either merge or go public.

The inventory of aluminum scrap that each smelter strives to maintain is determined by scrap availability, storage capacity, and operating cash on hand. Since aluminum is a light metal and the scrap material is bulky, large volumes of storage space are required. While some smelters operate with as much as a month of scrap in inventory, others operate with as little as a 2-day supply. A normal scrap inventory, however, is about a 2-week supply of scrap. Smelters operating with a small inventory can influence local prices when in danger of running out of scrap. When scrap does not arrive at the smelter on schedule, the operator must buy quickly from a local supplier by offering a premium price. This practice can--and often does--raise general scrap prices within the area.

3. Market Value of Assets

The market value of the assets of any of these plants is quite low unless the plant can be maintained as an operating unit. In general, the industry has been fairly negligent in the maintenance and upkeep of their facilities. Much of the equipment is single purpose equipment incapable of being utilized for any other purpose. On this basis, it is our estimate that these plants would have value somewhat less than the local land costs since the land values would have to be depressed by the cost of clearing up the sites. On the other hand, if the plant can be turned over to another operator who is able to operate it, the value can be substantially higher than this.

In one recent case, a large conglomerate shut down a smelting pland and was able to recover approximately 25% of book value on selling it to another smelter. In a case three years ago, another conglomerate shut down a plant they were unable to sell as a going operation and were able to salvage between 2 and 3 cents on the book value dollar.

4. Cost Structure

Cost sturctures vary dramatically in the industry depending on the type of scrap being utilized and the volume of operation. As an example, a plant utilizing a high percentage of dross metallics will have considerably higher operating costs, especially higher energy requirements. However, the cost of the drosses will be sufficiently low enough to offset these higher operation costs and return a better than average profit much of the time.

Typically the industry allocates approximately 5 1/2¢ to 6¢ per lb. for the cost of processing aluminum scrap into ingot (on a finished weight basis). The distribution of costs between fixed, such as rent, taxes, commercial and sales expenses and variables such as labor, fuel, fluxes, refractories, maintenance, will split up so that the essentially fixed costs are 2 1/2¢ of the 5 1/2¢. The variable costs are approximately 3¢. In certain operations where expensive scrap is used, which in turn minimizes in-plant production costs, conversion costs can go as low as 4 1/2¢ to 5¢, of which the commercial and selling expenses would represent about half and the inplant costs the other half. In plants that utilize high percentages of dross metallics the in-plant costs will go as high as 7¢ per lb. with 4 1/2 to 5¢ per lb. chargeable to operating costs.

In general, the commercial expenses in the industry, except for the smallest plants, are quite similar. In the case of the small plants, they tend to be somewhat less since the plant owner often will be selling relatively small quantities of material locally, reducing his sales expenses, possibly even completely eliminating his need for a sales force. Since many of these small plants are operated by "graduates" from the scrap industry, they have excellent commercial contacts and minimize their buying expenses to an extent that the larger companies cannot do.

5. Constraints on Financing Additional Capital

The general constraints on financing relate to the dollars needed for a particular project. The larger companies with a number of claims on their capital dollars from many divisions have been reluctant in the past several years to lay out large sums of money for plant improvements, pollution controls, etc. On the other hand, many of the small companies with close ownership have been able to find the capital to make at least minimal improvements, though most capital expenditures are paid for via retained income without the use of long-term financing (see Table III-5).

The small companies tend to do things on a less formalistic basis and tend to do a lot of "horseback" engineering and are adept at acquiring information and technology without great expense. These people have oftentimes been able to home-make quite capable machinery which would have cost several times its acquired cost if it had been purchased from normal commercial sources or if it had been engineered to their specific requirements.

As an example, in one large company owned by a conglomerate, a single furnace has almost $200,000 worth of air pollution control equipment on it involving afterburners and a scrubber. In another company where a sophisticated scrubber is used in conjunction with a baghouse system the unit cost for a single furnace is approximately $150,000. At the present time, a new small smelter is under construction, where the total cost of a sophisticated scrubber and a baghouse control will be accomplished for less than $40,000. It thus becomes obvious that constraints on capital availability vary within broad parameters relative to the flexibility and capability of the company.

There is little relationship between the price of primary ingot and secondary ingot in the long run. Since price is largely determined by the excess supply or the excess demand for each particular metal in the short-term or even anticipations of a supply/demand imbalance, the prices fluctuate and periodically cross. During the time in which an aluminum shortage exists, the result is an increase in the price of scrap. This, in turn, results in the primaries taking back their customers' scrap, thus causing more of a decrease in the scrap supply. This "snowball effect" thus pushes the price of secondary casting alloy above that of the primary alloy. Historically, this does not happen very often. In general, the price of secondary alloy ingot is 15 to 20 percent below that of primary ingot of the same alloy. There is a wide disparity between artificial or paper prices found in publications and the actual or market prices that exist. Unlike aluminum scrap prices, however, market prices for secondary aluminum ingot are lower than quoted prices. In late 1968, for example, 380 alloy was quoted in the American Metal Market as selling for 25 to 26 cents per lb. Selling price for 380 alloy on the east coast at that time was 22 to 22-1/2 cents per lb. Normally, the selling price for secondary aluminum ingot is higher in the Midwest than in any other region of the United States. Chicago prices for standard casting alloys are usually 1/2 cents per lb. higher than east coast prices and 1/2 cents per lb. higher than west coast prices.

F. IMPACT ANALYSIS

The purpose of this analysis is to assess the economic impact of the guidelines set forth by the Effluent Guideline Development Document for the secondary aluminum smelting industry. These guidelines are:

1. Best Practicable Control Technology (BPT) - to be met by industrial dischargers by 1977.
2. Best Available Control Technology (BAT) - to be met by 1983.
3. New Source Performance Standards (NSPS) - to be applied to all new facilities (that discharge directly to navigable waters) constructed after the promulgation of these guidelines (June 3, 1974).

The types of discharges regulated by the Effluent Guideline Development Document are waters from:

1. wet scrubbing of fumes
2. wet milling of residues
3. metal cooling

The effluent limitations for BPT set forth by the Effluent Guideline Development Document are shown in Tables III-6 and III-7. These guidelines regulate the quality of water discharged from chlorine fume wet scrubbing and from wet milling of residues, respectively. The effluent limitations for BPT with regard to metal cooling water and water from fluoride fume scrubbing is "no discharge" of water.

TABLE III-6

EFFLUENT LIMITATIONS FOR FUME SCRUBBER WASTEWATER GENERATED DURING CHLORINE DEMAGGING TO BE ACHIEVED BY JULY 1, 1977, BASED ON THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Parameter	Effluent Limitation (lb./1000 lb. of Magnesium Removed)
Total Suspended Solids	175
Chemical Oxygen Demand	6.5
pH	7.5-9.0

SOURCE: Effluent Guideline Development Document

TABLE III-7

EFFLUENT LIMITATIONS FOR WASTEWATER FROM RESIDUE MILLING TO BE ACHIEVED BY JULY 1, 1977, BASED ON THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Parameter	Effluent Limitation (lb./1000 lb. of product)
Total Suspended Solids	1.5
Fluoride	0.4
Ammonia (as N)	0.01
Aluminum	1.0
Copper	0.003
Chemical Oxygen Demand	1.0
p^H	7.5 - 9.0

SOURCE: Effluent Guideline Development Document

BAT limitations are "no discharge of pollutants to navigable waters" for all three types of discharge.

In addition, it is required that the standard of performance for new sources (NSPS) be such that there is "no discharge of pollutants to navigable waters" from metal cooling and residue milling operations. It is also required that the discharge of fume scrubbing wastewater from new sources be limited to those presented in Table III-6 for facilities using chlorine for demagging and to "no discharge" of scrubber wastewater for those using aluminum trifluoride for demagging.

1. Approach

The most realistic assessment of economic impact of pollution control regulations on an industry is based on a plant-by-plant and company-by-company basis. In the current study, time and budgetary considerations did not permit such an approach nor were incremental cost data available for each plant in the industry. Hence, the approach for the economic impact analysis was two-fold. Based on knowledge of the industry and technical considerations, the industry was divided into six segments, as discussed earlier, and attention was focussed on the segments with the highest incremental cost of pollution control. Based on the financial data (credit ratings, debt repayment history, net worth, etc.) on individual companies, an assessment was made of their capability to undertake significant capital investment.

2. Costs

The costs for conforming with the proposed regulations were provided by the Effluent Guideline Development Document and the Environmental Protection Agency (EPA) and are shown in Table III-8. The costs presented were examined enough to show that they are reasonable, but available time and budget did not permit a detailed analysis of the costs. Also, costs per pound of product will vary slightly with the size of the plant and amount of water being treated.

3. Impacted Segments

Table III-9 presents a description of the segmentation method used in this impact analysis, while Table III-10 shows the number of plants, employees, and production of aluminum alloy represented by each segment. The majority of existing plants in the secondary aluminum industry will require some degree of implementation and investment as shown in Table III-8 to conform to the effluent guidelines for BPT and BAT. However,

TABLE III-8

COSTS FOR MEETING PROPOSED EFFLUENT GUIDELINES

SECONDARY ALUMINUM SMELTING
(¢/lb. of product)

	BPT		BAT		NSPS	
Wastewater Type	Capital Investment	Annual * Cost	Capital Investment	Annual * Cost	Capital Investment	Annual * Cost
Metal cooling water	.037	.012	.037	.012	.037	.012
Wet Milling of residues	.39-.69	.15-.49	5.9	1.8	5.9	1.8
Wet Scrubbing on fumes						
- Chlorine demagging	.13	.068	.28	.19	.13	.068
- AlF_3 demagging	.58	.18	.58	.18	.58	.18

*Includes Depreciation and Interest

SOURCE: Effluent Guideline Development Document and the Environmental Protection Agency.

TABLE III-9

INDUSTRY SEGMENTS

SEGMENT	SIZE	PRODUCT	RAW MATERIAL
1	Large	Aluminum Ingot	Drosses
2	Small	Aluminum Ingot	Drosses
3	Large	Aluminum Ingot	Scrap Aluminum
4	Small	Aluminum Ingot	Scrap Aluminum
5	Large	Aluminum Billet, plate and sheet	Scrap Aluminum
6	Small	Aluminum Billet, plate and sheet	Scrap Aluminum

TABLE III-10

PLANTS, EMPLOYEES, AND PRODUCTION AND PERCENTS OF INDUSTRY TOTALS REPRESENTED BY EACH SEGMENT

	PLANTS		EMPLOYEES		PRODUCTION	
Segment	Number	Percent of Industry[1]	Number	Percent of Industry[1]	Millions of Pounds/Month	Percent of Industry[1]
1	10	10	1200	22	38.4	23
2	6	6	140	3	4.4	3
3	24	24	2500	44	71.0	43
4	19	19	770	13	15.3	9
5	9	9	450	8	25.0	15
6	1	1	20	<1	0.7	0.5
Totals	69	69	5080	90	154.8	94

1. Percentages may not add because of independent rounding.

SOURCE: ADL Estimates

these costs will not cause serious impacts in the way of production curtailments or plant closings except in a minor number of cases. We have made this assumption on the basis of two observations:

1. The financially weaker companies were closed during the general economic slow-down of 1969-71, therefore, only the stronger ones still exist.

2. Costs of more than 3¢/lb. of product for capital investment and 1¢/lb. for annual costs will cause severe impacts and possible plant closings.

The exceptions involve plants or departments of plants which do wet processing of drosses. These plants and departments will be severely impacted and could lead to plant closings or production curtailments due to the BAT requirements.

The closing of wet dross processing plants will affect segments 1, 2, and 3, although not all to the same degree. Segment 2 will be most severely impacted since the effect of the guidelines (BPT and BAT) will be to close three plants out of a total of six. An additional plant will be closed in segment 1. Closing of dross processing departments will occur at two plants in segment 3. The numbers of employees and quantities of production involved will be discussed in more detail later.

The major effect of NSPS guidelines will be the discouragement of building new wet dross processing plants. Any new dross processing plants will be forced to use dry processing methods, although this route presents several other problems to be described further on.

4. Price Effects

The probability of the industry being able to increase prices because of the additional cost of doing business is not likely. Instead, there probably will be an increase in the spread between the scrap and finished product price which will have to take place over a period of time. This means that the scrap suppliers will gradually reduce the price of scrap to the smelters. With the market as susceptible to supply and demand as it is, there have been times when large smelters and small have actually sold production at a substantial loss (see public figures relating to U.S. Reduction Co. 1970-71). These occurrences have been a result of the higher cost of labor and fuel and other ancillary costs coupled with depressed prices.

Secondary effects of the additional costs will be a profit squeeze during times of low demand and high supply, without an offsetting spread in profit when the reverse situation is true.

5. Financial Effects

The basic effect of increased pollution control equipment will be to decrease the overall profit of the industry a majority of the time but not allow it to increase beyond its present structure during the highly profitable periods which occur.

The capital will, in general, be available for all but the very smallest and most marginal of the operators. However, this money must come from the only capital sources that are generally available to these companies, i.e. short-term loans. This will mean that the ability of the industry to expand will be decreased somewhat except under conditions of tight supply, high prices, and high profits when this income can be used to pay for capital equipment.

6. Production Effects

Because of the additional requirements for more careful operation in order to stay within the design parameters of pollution control equipment,there has been a tendency toward somewhat reduced production. With the curtailment of wet dross processing by the presently used techniques, this will reduce the availability of scrap to the industry since at least a portion of the materials being reclaimed by wet processes today are not amenable to dry process without great expense and reducing the throughput through the dry milling systems.

It is our estimate that three small wet dross processors and one large wet dross processor would shut down completely and two plants which operate wet dross departments would be forced to shut down these departments. It is unlikely, if dumping is available, that these materials would be processed in new facilities within these plants.

The combined effect of plant and department closings would be a production curtailment of about five to six million pounds of aluminum per month or three to four percent of the total output of the 69 plants being considered.

The effect on the growth of the industry will be minimal so long as landfill is available for the disposal of smelter skims. On the other hand, if this is the only available endpoint for these materials, the profitability of the operations will decrease since the metallics that would otherwise be recovered from these materials will be lost to landfill.

7. Employment Effects

The curtailment of the wet dross processing departments in two plants would mean the loss of about 20 jobs at each of these plants or a total of 40 lost jobs. The three small wet processing plants and one large plant will probably have to be shut down since the technology that they will require and the capitalization to install this technology would be far beyond the capabilities of these companies. In general, this would mean the loss of a total of about 70 jobs at the three sites and 50 jobs at the remaining site.

This total of about 160 employees represents about three percent of the estimated 5080 employees at the 69 plants. In addition, there is the possibility because of the lower production output caused by the more stringent pollution control guidelines for all plants that an additional number of jobs may be lost in the industry. The total will probably not exceed five percent of the total force in the industry. Offsetting these plant closings will be the continued growth of the industry which will, in effect, allow these people to be re-absorbed into the industry.

8. Resultant Community Effects

The plants which will be forced to close completely consist of one located in California; a second located in the state of Washington; and two in Ohio. There will be production curtailment at one smelter in Pennsylvania and at one in Ohio.

The communities surrounding these plants will receive a minimal impact to the extent of no more than 50 jobs lost at each location. The number of employees involved in each of these plants is small in relation to size of the community in which each plant is located. It is, therefore, probable that these people will be able to be absorbed into the workforce of other industry.

It is extremely difficult to predict whether or not new plants will be built in the concerned areas. Plants will be built to process these drosses only if someone contemplates an economic return for a dry dross processing plant. It can be anticipated that the materials presently being processed by the existing wet dross processing plants would be processed by new plants using dry processes which would eliminate the water pollution aspects of the problem insofar as navigable streams are concerned. However, several other problems are encountered with the dry process:

1. High capital cost

2. High operating cost - mainly from increased energy requirements

3. Presents a solid waste consisting of highly water soluble salts which when leached by rain water presents a possible ground water pollution problem

4. Some materials being reclaimed by wet processes are not amenable to dry process without great expense and reduced throughput.

There is some possibility of secondary effects in these plants. For example, there will probably be a curtailment in the two smelting plants since they will have less scrap available to them from this relatively inexpensive source (drosses). At this point, the management of the individual companies will be presented with one of three choices:

1. Convert to a dry process, accepting the problems mentioned above.

2. Replace this cheap scrap with a more expensive scrap which does not have to be elaborately prepared and thus maintain the output of their furnaces.

3. Reduce the output of their furnaces rather than paying for the higher cost scrap. A reduction in output would also result in increased costs per pound of aluminum produced since they would be operating below capacity. It may also cause a possible reduction in the workforce in the rest of the plant.

G. LIMITS OF THE ANALYSIS

1. Accuracy

The plants which have been enumerated and the production outputs of the various plants are reasonably precise. The normal production from any one of these facilities has been closely estimated based on either plant visits or other personal inputs.

2. Range of Error

The range of error insofar as production capability is concerned is plus or minus ten percent. This range represents more the normal variations of overtime output during strong market periods than inaccuracies in the estimate.

3. Critical Assumptions

The two critical assumptions made in the previous analysis were:

1. The financially weaker companies were closed during the general economic slow-down of 1969-71, therefore, only the stronger ones still exist.

2. Costs of more than 3¢/lb. of product for capital investment and 1¢/lb. for annual costs will cause severe impacts and possible plant closings.

The first assumption is generally true in that a number of plants did close during the 1969-71 period and the entire industry is just beginning to see signs of good times ahead.

The typical margin in the industry is on the order of 1-2¢/lb. of product, therefore, an increase in annual costs of 1¢/lb. or more would be a severe impact. Annual costs for this type of equipment are usually about 30 percent of capital investment, thus, placing the critical amount of capital investment at about 3¢/lb. of product. It should be noted, however, that the above generalizations might not apply in specific instances. In the secondary metals industries it is not unusual to finance significant capital expenditures out of the cash flow or by using short-term debt when market conditions are favorable and profits are high.

4. Questions Remaining to be Answered

A relatively large amount of aluminum shot is manufactured for deoxidizing purposes as well as in a specific array of alloys for additions to zinc in the manufacture of zamak alloys. The production of shot will generally involve the use of large quantities of water in order to quench. The size and production requirements of a particular plant will determine the amount of water. The water temperature of the incoming water is critical to the proper production of shot with minimum hollow pieces in the product and with proper sizing.

This water is mainly used for thermal transfer and will not pick up any particular impurities, although obviously the evaporation of water from hard or even reasonably soft water will build up eventually so that it may be necessary for the disposal of water containing higher than normal dissolved solids.

The one way that water can be conserved in this type of operation is by means of a cooling tower. During most of the year in the northern section of the country this is quite competent to do the job. However, during the summer months and particularly during the summer in the southern section of the country the cooling effects of a cooling tower are generally not capable of giving the sufficiently low water temperature required for proper shot manufacture. It is for this reason that many companies have gone to one time through water flow even though the cost of water is somewhat higher this way than with the installation of cooling towers and recirculation.

If it was not possible to discharge this thermally loaded water to waterways or sewer systems, the use of a cooling tower followed by refrigeration to bring the termperatures down to about 65°F would be necessary. Alternative to this is a lower production rate and a higher reject proportion if the temperature were raised.

We have not assessed the economic impact of the proposed guidelines on these plants since there are many variables involved. These include:

1. Volumes of water used
2. Production rate
3. Type of shot produced
4. Water availability
5. Yearly temperature variation.

APPENDIX

ALUMINA PURCHASE CONTRACT SAMPLE

THIS CONTRACT made and entered into this _____________ day of April, 19
by and between Buyer, a corporation organized and existing under the laws of the _________________ (hereinafter referred to as Buyer), and Seller, a corporation organized and existing under the laws of _______________ (hereinafter referred to as Seller,

WITNESSETH

WHEREAS, Buyer will require a continuing supply of alumina for the operation of its aluminum reduction plant consisting of two pot lines having an aggregate capacity of approximately 54,000 short tons of aluminum per year, to be located in the vicinity of _______________, _______________; and

WHEREAS, Seller is willing to furnish alumina to Buyer upon the terms and conditions hereinafter stated, but in order to do so must construct additional facilities and rehabilitate its existing plant;

NOW, THEREFORE, the parties hereto, in consideration of the mutual covenants and conditions hereinafter set forth, agree as follows:

ARTICLE ONE

QUANTITY OF ALUMINA TO BE PURCHASED

1. Buyer agrees to purchase from Seller, alumina for the operation of its reduction plant and to pay the price or prices hereinafter set forth, and Seller agrees to sell and deliver to Buyer the said alumina, upon the terms and conditions as set forth in this Contract.

2. The said alumina so to be purchased and paid for by Buyer and sold and delivered by Seller shall be 54,000 short tons per annum. The first year shall run from the date of readiness under this Contract referred to in Article TEN, and each succeeding year shall commence running on the anniversary thereof.

3. Seller shall deliver to Buyer alumina, f.o.b., port, in bulk, in minimum 5,400 short ton lots per one vessel or such larger tonnage as Buyer may require. However, the quantity of one lot shall not exceed approximately 9,900 short tons.

4. Notwithstanding the foregoing agreement as to quantities per annum required to be delivered, it is expressly understood and agreed by and between the parties hereto, that within one month of the date of receipt by Seller of the Notice of Readiness under this Contract referred to in Article TEN, the parties hereto will negotiate in good faith for the purpose of agreeing upon the quantity of alumina Buyer shall be required to

order and take delivery of during the first year of its operation under this Contract.

5. In case such quantity has not been agreed upon within the one-month period as aforesaid, the minimum quantity which Buyer shall order, and take delivery of, in the first year of operation shall be 42,000 short tons.

6. Each annual tonnage to be ordered and delivered after the first year of operation shall be discussed and agreed upon by both parties not later than six (6) months before the beginning of each year of operation. In case agreement has not been reached, the provisions of Paragraph 2 of this Article ONE above shall govern with respect to the quantity to be ordered and delivered during the following year of operation.

7. It is recognized that there may be minor variations in tonnage delivered or purchased hereunder from those tonnages specified in or agreed to in accordance with the preceding paragraphs of this Article ONE. Such variations shall not be in breach of this Contract giving rise to a right to damages or other remedy to either party hereto.

ARTICLE TWO

SPECIFICATION OF ALUMINA

1. Seller shall supply Buyer with such alumina as its analytical value shall, in each shipment and at the port of departure, conform to the below-mentioned specification. The methods of sampling and analysis shall be in accordance with the provisions of Article THREE.

Loss on Ignition	1.00% Max.
SiO_2	0.04% Max.
Fe_2O_3	0.05% Max.
TiO_2	0.01% Max.
Na_2O	0.65% Max.
Moisture Adsorption	2.00% Max.
All other impurities not to exceed	0.01% Max.

2. Alumina shall be white and powdery and have a screen analysis of about 50 per cent passing through a 325 mesh Tyler standard screen.

3. The loss on ignition value specified above shall be typical of freshly calcined alumina and shall consist chiefly of residual water of

crystallization with only a trace of adsorbed moisture. Moisture adsorption shall consist of residual water of crystallization plus total moisture that can be adsorbed through exposure to an atmosphere of relative humidity of 44 per cent.

ARTICLE THREE

SAMPLING AND ANALYSIS OF ALUMINA

1. Seller shall sample and analyze, at its own cost, the alumina to be shipped at the time of loading each vessel in accordance with the Standard Methods adopted and practiced in ______ by Seller. The statement of the methods of sampling and analysis as referred to above is attached to this Contract and is made a part hereof. Buyer shall have the right to inspect the sampling procedures of Seller.

2. Seller shall prepare a report on analysis in accordance with its Standard Methods and shall send it by airmail to Buyer without delay.

3. Samples shall be promptly air-expressed by Seller to Buyer together with a report of all such analyses. Buyer shall have the right to check the samples, such testing to follow standard testing procedures. Buyer shall have the right to re-sample and re-analyze the shipment at the time of unloading, such sampling and analyses to follow standard sampling and testing procedures and to take into account salt water or other contamination resulting from the voyage across the Pacific.

4. Seller and Buyer will both make available, upon request of either for mutual inspection, any and all records of tests and analyses made of the alumina.

ARTICLE FOUR

TIME OF DELIVERY

1. When Seller has completed the loading of the vessel dispatched in accordance with the vessel-arrangement schedule submitted by Buyer, as provided for in Article FIVE, with the alumina f.o.b. port, in bulk, and the bill of lading has been issued, the alumina shall be deemed to have been delivered to and taken by Buyer.

2. All the expenses of materials and installation for shifting boards shall be borne by Buyer, and the trimming shall be made at the cost of Seller.

ARTICLE FIVE

VESSEL-ARRANGEMENT SCHEDULE AND DELAY OF DISPATCHING VESSELS

1. Buyer shall take delivery of the quantity of alumina agreed upon under Article ONE, in accordance with a vessel-arrangement schedule providing for the arrival of vessels at reasonably spaced intervals, which take into account procurement from more than one supplier in _____ and the maximum and minimum quantities referred to in Paragraph 3 of Article ONE, during each year, and such vessel-arrangement schedule shall be submitted to Seller four (4) months in advance of the dispatch of the first vessel for each year.

2. Buyer shall, whenever it dispatches a vessel, notify Seller at least three (3) weeks in advance of the expected time of arrival of such vessel at port and furnish Seller the name, tonnage, owner and charterer of the vessel to enable Seller to make arrangements for loading.

3. Buyer shall, at the same time it gives Seller the notice referred to in Paragraph 2 above, notify Seller, in writing, of the pertinent conditions of the charter party necessary for Seller to complete the loading.

4. In case it is foreseen clearly at the time of notification referred to in Paragraph above that the arrival of a vessel may be later than the last day of the scheduled period set forth in the annual vessel-arrangement schedule, Buyer shall notify Seller of the reason for the delay, in as much detail as possible.

5. In case a vessel arrives more than fifteen (15) days after the last day of the scheduled period set forth in the annual vessel-arrangement schedule and more than ten (10) days after the expected time of arrival referred to in Paragraph 2 above, Buyer shall pay Seller as liquidated damages for each day after the tenth day from such expected time of arrival the sum of Four Hundred U.S. Dollars (U.S. $400). For the purpose of this Paragraph, a vessel shall be considered to have arrived at Seller's port when it is ready to proceed to anchor there.

ARTICLE SIX

LOADING RATE PER DAY, LAYTIME AND DEMURRAGE AND DISPATCH

1. Loading of alumina shall be made at the rate of 2,200 short tons per day. The free loading time shall be limited to weather working days, Sundays and national and local holidays always excepted.

2. The laytime shall commence at 4:00 p.m. when the notice of preparedness is tendered by the master of the vessel and accepted by the authorized personnel of the _____________ plant of Seller at any time during office hours before noon. In case such notice of preparedness is rendered and

accepted at any time during office hours in the afternoon, the laytime shall commence at 8:00 a.m. on the following day. Seller shall not be required to accept a notice of preparedness in the afternoon on Saturday.

3. In case the completion of the loading is delayed over the period counted on the basis of the loading rate of 2,200 short tons per day, Seller shall pay Buyer demurrage at the rate of One Thousand U.S. Dollars (U.S. $1,000) per day or pro rata for part of a day.

4. Buyer shall pay Seller dispatch money at the rate of Five Hundred U.S. Dollars (U.S. $500) per day or pro rata for part of a day for all laytime saved in loading.

5. If a vessel arrives more than two days before the expected time of arrival referred to in Paragraph 2 of Article FIVE, the loading of alumina and demurrage shall be computed from 8:00 a.m. of the second day before such expected time of arrival even though such loading may actually begin before that time.

ARTICLE SEVEN

WEIGHING

Weighing by draught at Seller's port shall be at Seller's cost and shall be final, after it has been certified by an internationally recognized surveyor, to be appointed by Seller every six (6) months of operation under this Contract, subject to the agreement of Buyer, which agreement shall not be unreasonably withheld. Copies of weight certificates shall be sent to Buyer along with shipping documents.

ARTICLE EIGHT

PRICE AND PRICE ADMUSTMENT

1. The base price to be paid for the alumina delivered by Seller to Buyer shall be Sixty-eight Dollars (U.S. $68.00) per short ton, free on board, port. Such price is based upon the arithmetic average of the current published market prices in the United States as of the date of this Contract, of three corporations producing pig aluminum in the U.S. (namely: Aluminum Company of America, Kaiser Aluminum & Chemical Corporation and Reynolds Metals Company). This average price is at present Twenty-four U.S. Cents (U.S. $0.24) per pound of aluminum pig of 99.0 per cent average guaranteed minimum purity.

2. However, the base price referred to above shall be increased or decreased, as the case may be, by Three U.S. Dollars (U.S. $3.00) per short ton for each One U.S. Cent (1¢) increase over or decrease under Twenty-four U.S. Cents (U.S. $0.24) per pound in the average price per pound referred to above, at the time of issuance of the bill of lading for the alumina shipped. Notwithstanding the foregoing provisions, such base

price shall be increased or decreased by only Two Dollars and Fifty Cents U.S. (U.S. $2.50) per short ton for the first One U.S. Cent increase over or decrease under such Twenty-four U.S. Cent price, at the time of issuance of the bill of lading for the alumina shipped.

3. If the variation in the average price per pound referred to above is only a fraction of One U.S. Cent (1¢), the adjustment of the price of alumina shall be made in due proportion thereof.

4. Buyer shall notify Seller of the latest published market prices mentioned above by telegraph and in writing immediately after they have been made public.

ARTICLE NINE

MEDIA OF EXCHANGE

1. All payments and prices referred to in this Contract shall be made and computed in the United States Currency.

2. Notwithstanding the foregoing provisions, subject to obtaining the necessary approvals from governmental authorities in ________________ or the ____________, Buyer may, with the agreement of Seller, make part or all of the payments for alumina provided for hereunder by deliveries of aluminum pig to Seller.

ARTICLE TEN

APPROVALS, BASIC TERM AND TERMINATION OF CONTRACT

1. Seller shall have until ________________________ in which to obtain permission or approval of this Contract from the ______________ Government authorities in accordance with the ____________ laws; provided, however, that such period shall be extended to _______________ if such permission or approval shall not be received on or before such earlier date.

After the permission or approval of the __________ Government authorities is obtained, Buyer shall have until   in which to obtain approval of this Contract by (a) the Government of ___________, acting through its General Services Administration, and (b) the banking institutions referred to in Article FOURTEEN participating in the financing of the construction of Buyer's aluminum reduction plant. If Buyer obtains approvals abovementioned within such period, Buyer shall promptly notify Seller and this Contract shall remain in full force and effect. If such approvals are not obtained within such period, this Contract shall be null and void and of no force and effect whatsoever. Buyer shall notify Seller promptly after ____________ if such approvals have not been obtained.

2. The basic term of this Contract shall be for a period of ten (10) years following the date of readiness under this Contract, which date

shall be the date when Buyer desires to commence the supply of alumina for its aluminum reduction plant, as fixed by written Notice of Readiness from Buyer to Seller. Such date of readiness shall be fixed no earlier than ________________________ and no later than ____________________, and the Notice of Readiness fixing such date shall be given at least one hundred and eighty (180) days in advance of such date.

3. Either party may terminate this Contract on any date after the expiration of five (5) years from the date of readiness referred to in Paragraph 2 of this Article. Such termination shall be effective only if the party desiring to terminate has given the other party written notice of intention to terminate (which notice may be given prior to the end of such five-year period) at least eighteen (18) months prior to the date of termination.

ARTICLE ELEVEN

CANCELLATION OF CONTRACT ON FAILURE TO TAKE FIRST DELIVERY

Seller may cancel this Contract by a notice in writing to Buyer in the event Buyer does not take delivery of any alumina pursuant to this Contract within three (3) months after the date of readiness fixed in accordance with Paragraph 2 of Article TEN. The right of cancellation provided for in the preceding sentence shall not be exercisable if the failure to take delivery of alumina arises out of the causes specified in Article TWELVE but such non-exercise of the right to cancel shall not extend beyond six (6) months from the occurrence of such causes.

ARTICLE TWELVE

FORCE MAJEURE

Any non-performance of its obligations under this Contract by either party hereto shall not be a breach of this Contract if such non-performance shall arise out of or result from an inability to perform on the part of such party or from the failure of Seller to have the supply or of Buyer to have the requirements of alumina covered by this Contract, which inability or failure shall be caused (1) by any typhoon, strike, labor difficulty, lockout, fire, explosion, flood, war, hostilities, riot, rebellion, revolution, blockage, quarantine restrictions or other act or acts of the respective governments of the parties, whether legal or otherwise, acts of public enemies, or the elements, or (2) by any other contingency which is beyond the control and without the fault or negligence of Buyer or Seller. The term of this Contract shall be extended by the length of time during which any such inability to perform or failure of supply or requirements shall exist. Each party hereto agrees to give notice to the other within fifteen (15) days after the occurrence of any such inability or failure and to use diligence to remove or remedy any such inability or failure. Notwithstanding the foregoing provisions in this Article, if there is a non-performance of obligations under this Contract (which by reason of the provisions of this Article shall not be a breach of this Contract) by either party for a period longer than six (6) months, then the other party may, at its option, elect to terminate this Contract by written notice given prior to the resumption of performance hereunder, and upon such termination, neither party shall have any liability to the other hereunder in respect of such non-performance.

ARTICLE THIRTEEN

ALUMINA FROM OTHER SOURCES

Seller may deliver alumina from any source other than from its own plant, provided that the quality thereof shall conform with the specification stipulated in Article TWO, and provided further that the delivery of such alumina shall not cause or involve any greater cost to Buyer, due to the increased price of such alumina, the cost of shipping or transportation thereof and any other reason, than the shipment of alumina made directly from Seller's alumina plant to Buyer.

ARTICLE FOURTEEN

ASSIGNMENT OF CONTRACT

Buyer may, at any time, upon sixty (60) days' notice in writing to Seller, assign this Contract to any of its controlled subsidiary or controlled affiliated corporations, provided that such assignment shall not operate to relieve Buyer from any of its obligations hereunder, unless otherwise agreed upon between the parties.

It is further agreed by and between the parties that Buyer may at any time assign this Contract to Bank of America National Trust and Savings Association, The Chase Manhattan Bank and The First National City Bank of New York as security for loans to be made by such banks to Buyer for financing the construction of Buyer's aluminum reduction plant. Buyer shall at all times remain bound by the terms of this Contract as fully as if such assignment had not been made. In the event of any sale or transfer of this Contract by such banks, by reason of the occurrence of a default under the Loan Agreement between Buyer and such banks, such sale or transfer shall be accepted by the purchaser or transferee, subject to the express condition that such purchaser or transferee shall be thereafter bound by the terms of this Contract as fully as if such purchaser or transferee alone had executed this Contract in place of Buyer. Such assignment shall provide that so long as Buyer is not in default under the Loan Agreement between Buyer and such banks, Buyer shall have the right to operate under this Contract as though such assignment had not been made, and that such banks do not assume any liabilities under this Contract and shall not be reason of such assignment become liable in any respect whatsoever to Seller. A copy of any such assignment and any such acceptance by such purchaser or transferee shall be sent promptly to Seller.

ARTICLE FIFTEEN

PAYMENT

1. Except as may be otherwise agreed, payment by Buyer shall be made by irrevocable letter of credit in favor of Seller against shipping documents. This letter of credit shall cover ten per cent more than the value equivalent to the amount of scheduled shipment. However, Seller can only draw on such letter of credit referred to in the preceding sentence in each case an amount equivalent to the price for the quantity actually shipped and the fee for consular invoice issued by the Consulate in Seller's country.

2. The letter of credit shall be opened thirty (30) days in advance of the expected date of arrival referred to in Paragraph 2 of Article FIVE for the first shipment and ten (10) days for all the following shipments.

3. The letter of credit shall be extended as required.

ARTICLE SIXTEEN

NOTICE

1. Any notice provided for in this Contract shall be given by one party to the other by registered mail with return receipt requested and shall be addressed to the office of Buyer or to the office of Seller, as the case may be.

2. Except as otherwise provided, the said notice shall come into effect when it reaches the party to whom addressed.

ARTICLE SEVENTEEN

ENTIRETY OF CONTRACT

This Contract represents the entire agreement between the parties hereto with respect to the subject matter hereof. This Contract may be modified or amended only by mutual agreement of the parties expressed in writing. This Contract has been signed by the authorized corporate officers of the respective parties. The duplicate counterparts of this Contract have been prepared and executed in English and shall be binding upon both parties and determinative of the rights of the parties.

This Contract shall come into effect and be interpreted in accordance with law of Seller's country.

ARTICLE EIGHTEEN

ARBITRATION

Any dispute arising under or by virtue of this Contract shall be referred to arbitration by the parties. Such arbitration shall take place in Japan and shall be in accordance with the regulations of the Commerical Arbitration Association and the laws of Seller's country. The party which desires arbitration must give written notice to the other party of a demand for arbitration, together with the name of the arbitrator whom it appoints and the general nature of the dispute or disputes. The other party shall appoint an arbitrator within thirty (30) days, and if it shall fail to do so, the arbitrator appointed by the first party shall be the sole arbitrator. If two arbitrators shall be appointed, they shall select a third arbitrator within thirty (30) days, and if they fail to do so, the third arbitrator shall be appointed by the Commercial Arbitration Association of Seller's country. In any event, the arbitrator or arbitrators shall be chosen from the Panel of the Commercial Arbitration Association of Seller's country. The award of two of three arbitrators shall be final and conclusive. In case there is one arbitrator only, the award of such an arbitrator shall be final and conclusive.

ARTICLE NINETEEN

PRICE RE-DETERMINATION

If either party considers, during the term of this Contract, that there have arisen changes in the economic conditions, re-determination of or change in the foreign exchange rate, major changes in the prices of raw materials which are not compensated for by changes in the price hereunder and/or other similar causes which would result in loss on the part of such party, such party may at any time propose in writing to the other party for re-determination of price, and the parties shall then proceed to discussions within thirty (30) days.

If upon expiration of sixty (60) days after the commencement of such discussions the parties hereto fail to agree upon a renegotiated price to be effective during the remainder of the term of this Contract, the price provisions in this Contract shall continue to be in effect until otherwise modified by the parties by mutual agreement.

ARTICLE TWENTY

CANCELLATION OF CONTRACT ON DEFAULT

The parties hereto clearly recognize that prompt delivery and taking of the alumina herein contracted for in accordance with the terms hereof are of the essence of this Contract and that delays and default and/or the failure to deliver or take said supplies in accordance with the terms hereof will cause damage and loss to Seller or Buyer, as the case may be.

Subject to the provisions of Article TWELVE, if Seller fails to make delivery of the supplies of alumina in accordance with this Contract within sixty (60) days after it is required to do so under the terms of this Contract, Buyer may at its option, by written notice of default to Seller, cancel this Contract in whole or in part.

In the event either party exercises its right to cancel under this Contract, it may then proceed to exercise such other and additional remedies, at law, or by other means within the law, as are available to it, including in the case of Seller the offsetting of any damages it may have suffered against the advance payment referred to in Article TWENTY-ONE or the unpaid balance thereof.

ARTICLE TWENTY-ONE

ADVANCE PAYMENT

Buyer shall advance to Seller within three (3) months from the date when it has obtained all approvals referred to in Paragraph 1 of Article TEN, the sum of Seven Hundred Thousand U.S. Dollars (U.S. $700,000), which amount shall be an advance payment for alumina to be delivered by Seller under this Contract. Such advance payment shall be applied as an offset against the purchase price payable by Buyer for alumina to be delivered hereunder by Seller, as follows:

(a) The purchase price of the first 50,000 short tons delivered during the year following the third anniversary of the making of such advance payment shall be reduced by Four Dollars and Twenty Cents U.S. (U.S.$4.20) per short ton.

(b) The purchase price of the first 50,000 short tons delivered during the year following the fourth anniversary of the making of such advance payment shall be reduced by Four Dollars and Twenty Cents U.S. (U.S. $4.20) per short ton.

(c) The purchase price of the first 50,000 short tons delivered during the year following the fifth anniversary of the making of such advance payment shall be reduced by Five Dollars and Sixty Cents U.S. (U.S. $5.60) per short ton.

Seller will pay interest at the rate of 5 per cent per annum on said advance payment or on the unpaid balance thereof. Such interest shall be payable to Buyer annually in U.S. Dollars on the anniversary date in each year of the making of the advance payment.

In the event a default under this Contract on the part of either party shall occur, or this Contract shall be cancelled as herein provided, then the advance payment herein provided for or the balance thereof shall forthwith become due in U.S. Dollars to Buyer with interest at the rate of 5 per cent per annum, subject to the last paragraph of Article TWENTY.

In the event the advance payment herein provided for shall not be made by Buyer to Seller within the time above specified, Seller may cancel this Contract and thereupon it shall be relieved of its obligation to supply alumina to Buyer and shall not be liable to Buyer for any damages whatsoever for so doing.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be executed by their duly authorized officers and their corporate seals to be hereunto affixed by authority of the Board of Directors of each of the parties, as of the day and year first above written.

SELLER

By: ______________________________

BUYER

By: ______________________________